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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE COUNTRY AROUND NORWICH.

(EXPLANATION OF QUARTER SHEETS 66 N.E. AND 66 S.E. OF THE ONE-INCH GEOLOGICAL SURVEY MAP OF ENGLAND AND WALES.)

BY

HORACE B. WOODWARD, F.G.S.

(Notes by J. H. BLAKE, Assoc. M. Inst. C.E., F.G.S., and C. REID, F.G.S.)

Lists of Fossils revised by R. ETHERIDGE, F.R.S.

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NOTICE.

One of the earliest geological descriptions of Norfolk was published by Samuel Woodward in 1833. To the grandson of this old geologist has been confided the task of preparing the present Geological Survey Memoir, which I think will be found not unworthy of its author and his name.

The Chalk of Norfolk is interesting as probably exhibiting higher beds than occur elsewhere in England. The very full lists of fossils give great value to the Chapters on the Cretaceous Beds and the Crag.

In the grouping of the Glacial Beds the author has simply adopted a classification applicable to the district, being of opinion that no general classification can be established until the Glacial Beds are minutely mapped over much larger areas. This work is now in progress by the Geological Survey. As it proceeds we shall probably learn that these beds are less complex than they appear to be, and that many of the divisions have only a local value.

ANDREW C. RAMSAY,
Director General.

Geological Survey Office,
London,
November 11th, 1881.

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NOTICE.

THE Geological Survey of the district described in this Memoir (which includes the greater part of the country over which the Norwich Crag is exposed) was commenced in 1875 and completed in 1880.

For the greater portion of the work Mr. H. B. Woodward is responsible.

Mr. J. H. Blake, from his station at Yarmouth, mapped portions of the eastern borders of the district, comprising the tract north of the Yare and east of Hasingham, Fishley, and the Hundred Stream. Mr. Clement Reid mapped a small area around Sutton, Catfield, and Potter Heigham; and a large area in the Waveney Valley, east of Alburgh and Topcroft, and south of Loddon, Raveningham, and Haddiscoe. Both officers have contributed notes on the districts examined by them, which are duly acknowledged in the text. Mr. W. Whitaker and Mr. F. J. Bennett have furnished some of the records of well-sections; and the former has, as usual, lent very substantial aid in the preparation of the Bibliographical Appendix, which contains references to no less than 680 works.

In dealing with the Crag beds in a comprehensive way, and in using the term Upper Crag or Norwich Crag Series, Mr. Woodward has not been inattentive to the detailed labours of resident and other geologists; but he found that, owing to the variable nature of the beds, the several local divisions, made out in certain so-called "typical" sections, were not persistent, and could not be laid down on the map. Moreover, the very fact of this uncertainty in tracing out and correlating minute divisions has led to considerable diversity of opinion among geological writers.

The lists of fossils have been carefully compiled from the specimens collected by the officers on the Geological Survey, and from other specimens in private collections, which were examined and named by Mr. Etheridge, Mr. George Sharman, and Mr. E. T. Newton. With these have been included all well-authenticated species, recorded in the works of the Palæontographical Society, and other publications, to which references are made in the text.

Nearly 50 species have thus been added to the list of the Upper Chalk fossils of Norwich; while the list of Upper Crag fossils is the most complete, so far as the localities are concerned, that has been published. The list of fossils from the flint-gravels likewise contains numerous species from the district not hitherto recorded. These lists have been revised by Mr. Etheridge.

I may also mention that Mr. Woodward surveyed the geology of the city of Norwich on a copy of Mr. A. W. Morant's large map on a scale of 5 chains to an inch, which will be deposited in the Geological Survey Office for reference.

Geological Survey Office,
28, Jermyn Street, S.W.
22nd October 1881.

H. W. BRISTOW,
Senior Director.

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PREFACE.

The share taken by my colleagues in the Geological Survey of the country around Norwich having been explained by the Director in his prefatory notice, and a summary of their notes being given at the end of the Table of Contents, it remains for me to acknowledge my obligations to many geologists in Norwich and elsewhere, who have furnished me with much information and contributed to render pleasant my sojourn in the district.

Messrs. John Gunn, Searles V. Wood, and F. W. Harmer have at all times placed their stores of information at my disposal, while the excellent Map of Messrs. Wood and Harmer, commenced in 1865 and published on a reduced scale in 1872 (by the Palæontographical Society), naturally paved the way for all future field-geologists. If I have not followed their advice in all matters relating to classification, it is with no disrespect to their extended labours. The conclusions of other distinguished geologists, whose writings are enumerated in the Appendix, shows that there is room for much diversity of opinion ; and I have endeavoured to carry on my work with a due appreciation of the many labourers in the same field, while forming an independent view on the many puzzling questions that have come before me. My work, however, has been essentially to record facts, the full discussion of the theoretical questions not coming within the province of a Geological Survey Memoir. But I may candidly state that the mapping and classification of the Pliocene and Post-Pliocene deposits in East Anglia has proved more difficult than any field-work I had been previously called upon to undertake. Moreover, in the summer months (June to August) the mapping in such an exclusively agricultural district is much hindered by the crops of corn and grass.

Mr. Robert Fitch, the late Mr. John King and his son Dr. H. D. King, Dr. W. M. Crowfoot, Mr. E. T. Dowson, and Mr. T. G. Bayfield have most kindly exhibited their fossil treasures to myself and colleagues in the field, as well as to Mr. Etheridge and Mr. E. T. Newton ; and they have lent some of their most valued

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specimens for the purpose of closer study in London. To Mr. James Reeve (of the Norwich Museum), Mr. S. C. Sothern, Mr. H. Norton, Dr. J. E. Taylor, Mr. S. W. Utting, and Mr. J. Quinton, jun., I am likewise indebted for notes and information, and for the use of books. To my uncle, Dr. Henry Woodward, I am beholden for the loan of MSS., the work of my grandfather, Samuel Woodward, termed by Mr. Gunn "the "Father of Norfolk Geology," in whose footsteps I have been proud to follow over a portion of the county.

In conclusion I may add that I shall be grateful for information concerning errors or omissions in the Maps or Memoir; and in the words of an old writer, "if I have done well, and as is fitting the story, it is that which I desired; but if slenderly and meanly, it is that which I could attain unto."

HORACE B. WOODWARD.

Fakenham,
29th October 1881.

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CONTENTS.

CHAPTER I.—INTRODUCTION.

Page.

Area - - - - - - - - - 1
Heights - - - - - - - - - 1
Rivers - - - - - - - - - 2
Broads - - - - - - - - - 3
Geological Formations - - - - - - - - 4

CHAPTER II.—CRETACEOUS.

Gault - - - - - - - - - 7
Upper Greensand - - - - - - - - 7
Chalk - - - - - - - - - 8
General Remarks - - - - - - - - 8
Fossils, with List - - - - - - - - 10
Flints - - - - - - - - - 20
Paramoudras - - - - - - - - - 22
List of Fossils found in the Flint-gravel of the neighbourhood of Norwich - - - - - - - - 26
Economic Products - - - - - - - - 28

CHAPTER III.—TERTIARY.

Eocene - - - - - - - - - 31
Pliocene—Upper Crag—Norwich Crag Series - - - - 31
General Remarks - - - - - - - - 31
List of Fossils - - - - - - - - 41
Local Details:
I. Bure Valley - - - - - - - 56
II. Wensum Valley - - - - - - - 66
III. Yare Valley - - - - - - - 68
Tese Valley - - - - - - - 69
IV. Waveney Valley - - - - - - - 85

CHAPTER IV.—GLACIAL DRIFT.

General Remarks - - - - - - - - 90
A. Stony Loam or Brickearth (Contorted Drift) - - 91

Digitized by Google

Page.

B. Sand and Gravel ("Middle Glacial") - - - 92
Local Details:
1. Area north of the Yare - - - - - 93
List of Mollusca from Billockby - - - - 95
2. Area between the Yare and the Waveney - - - 103
3. Area south of the Waveney - - - - - 108
C. Laminated Brickearth - - - - - - 110

CHAPTER V.—GLACIAL DRIFT (continued).

D. Boulder Clay (Chalky Boulder Clay) - - - 115
Local Details:
1. Area north of the Yare - - - - - 118
2. Area between the Yare and the Waveney - - - 121
3. Area south of the Waveney - - - - - 128
E. Gravel (Cannon Shot Gravel) - - - - - 128

CHAPTER VI.—SURFACE PHENOMENA.

Disturbed Chalk - - - - - - - - 134
Pipes in the Chalk and other Deposits - - - - 138

CHAPTER VII.—ALLUVIAL DEPOSITS.

Waveney Valley - - - - - - - - 141
Yare Valley - - - - - - - - - 141
Bure Valley - - - - - - - - - 142
Depth of Valleys - - - - - - - - - 143
Peat - - - - - - - - - - 143
Fossils - - - - - - - - - - 144
Flint Implements - - - - - - - - 145

CHAPTER VIII.—PHYSICAL GEOGRAPHY.

Origin of Scenery—The Marshlands - - - - - 146
Floods, &c. - - - - - - - - - 149

CHAPTER IX.—ECONOMIC GEOLOGY, &c.

A. Water Supply and Wells - - - - - 154
Natural Wells and Mineral Springs - - - - 168
B. Prospects of Coal - - - - - - 168
List of Minerals - - - - - - - - 170

APPENDIX.

List of Papers, &c., on the Geology of Norfolk - - - - 171

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Page.

Diagram to show the possible Occurrence of Coal Measures in the Eastern Counties - - - - - - - - - - 6

[For Explanation of Plates, *see* end of Volume.]

REFERENCES TO NOTES CONTRIBUTED BY COLLEAGUES.

Whitaker, W.—pp. 156, 166, 171.

Dalton, W. H.—89, 133,

Bennett, F. J.—161, 162, 167.

Blake, J. H.—66, 77–80, 94, 100–103, 119, 120, 142, 143.

Reid, C.—85–88, 91, 106–110, 113, 114, 126, 127, 133, 141, 142, 145, 156–163, 165–167.

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THE

GEOLOGY

OF THE

COUNTRY AROUND NORWICH.

CHAPTER I.—INTRODUCTION.

Area.

An area of about 412 square miles is represented in quarter-sheets 66 N.E. and 66 S.E. of the Geological Survey Map; this includes a small portion of Suffolk, in the south-eastern corner, and part of Norfolk. It contains the city of Norwich, with the towns of Loddon and Long Stratton in Norfolk, and the towns of Beccles and Bungay in Suffolk.

The area consists of a gently undulating plain nowhere so much as 200 feet above the sea-level. It is intersected by the valleys of the Bure, the Yare, the Waveney, and their tributaries. These valleys in their lower courses open out into extensive areas of marsh-land, and they are characterized here and there by the shallow freshwater lakes known as "Broads," which are connected with the rivers, although not always situated in their direct channel.

The land is mostly under cultivation, the larger areas of waste being the heaths of Mousehold and Horsford. No traces of old forest remain, but there are many plantations, especially in the parishes of Shottesham, Felthorpe, Haveringland, Hevingham, and Stratton Strawless. A characteristic feature of the country is that it appears well wooded, and it has been remarked that in travelling through it one seems to be on the verge of a forest which is never reached, a deception that arises from the numerous trees (mostly oak and ash) growing in the hedgerows.

Heights.

Although the term "hill" is applied in a few places, there is scarcely any isolated elevation worthy of the name. The higher grounds of Strumpshaw and Poringland (about 150 feet above the sea-level), however, afford pleasant prospects of the country; while on Mousehold, at St. Michael's Chapel (Kett's Castle), and St. James' Hill, good views of the city and of the valley of the Wensum can be obtained.

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A few heights have been published by the Ordnance Survey,* of which the following may be mentioned:—

Acle Church	33	feet above	sea-level.
Blofield Church	44	„	„
Burlingham, St. Peter's Church	94	„	„
Costessey, Dereham Road	142	„	„
Heigham, "Earl of Leicester" Inn	60	„	„
Lakenham, new church	125	„	„
Norwich, Castle	108	„	„
„ Cathedral	24	„	„
„ City Gaol	90	„	„
„ St. Giles' Church	82	„	„
Postwick Church	47	„	„
Thorpe Church, Norwich	15	„	„
Thorpe Hamlet Church	46	„	„
Witton Church	68	„	„

Rivers.

I.—The *Bure*, which rises in the Park at Melton Constable, makes its first appearance in the area at Lammas and Buxton, whence it takes a south-easterly course as far as Acle and Stokesby; it finally falls into Breydon Water near Yarmouth. On its right bank, it receives (1) the Hor, which, flowing through Horsford and Horsham St. Faith's, forms the southern boundary of Horstead parish; (2) the Panxworth stream, which flows through Walsham Broad, and by the Fleet Dyke. On its left bank the Bure receives, (1) the Ant, which rising near Antingham, flows southward through Barton Broad; (2) the Thurne (spelt also Thone, Thirne, or Thyrn), which rises near Horsey and Martham, and from the fact of its separating the hundreds of Happing and West Flegg is also known as the Hundred stream; (3) the Muck Fleet, which, flowing from Filby Broad, joins the Bure a mile below Acle Bridge.

The Bure drains an area of about 338 square miles; it is about 100 feet broad at its widest part in the district. The drainage and navigation are said to be impeded by mud-banks.

II.—The *Yare* rises near Shipdham, and in several streamlets that unite at Hardingham Mills. It appears in the area at Bauburgh, and, flowing eastwards, leaves it near Reedham, eventually falling into the sea at Yarmouth. It receives on its right bank (1) the Tese or Taus (spelt in a variety of other ways, Tau, Tase, Tacs, Tas, Tass, Tesse) which rises near Hardwick and flows by Tasburgh (*Ad Taum*), where a deep ford gave rise to the name of the hundred, Depwade or Deepwade; (2) the Chet or Ket, which rising at Poringland flows between Loddon and Chedgrave, joining the Yare at Hardley Cross, which is the boundary of the jurisdictions of the Norwich and Yarmouth Corporations. On its left bank the Yare receives (1) the Wensum, an affluent which at the junction near Trowse is by far the more important river,

* Abstracts of the principal lines of spirit-levelling in England and Wales. By Major-Gen. Sir H. James.

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and indeed in ancient documents the term Wensum has sometimes been applied below Norwich to the confluent rivers. The Wensum rises in one stream near Horningtoft and Colkirk Heath, in another at Wicken Pond, Syderstone, and in a third at the villages of East and West Rudham. It appears in the area near Taverham, and flows through Norwich. In this city it formerly received the Cockie stream, which traversed the valley in which the market-place is situated, and fell into the Wensum near the "Duke's Palace" Inn. The Yare also receives on its left bank (2) the Plumstead Stream, formerly called the Ger, which joins it between Brundall and Buckenham.

The Yare and Wensum together drain an area of 533 square miles. Eastwards of Whitlingham the river is from 10 to 15 feet deep, and its general width is about 150 feet. Between Norwich and Yarmouth, according to Sir John Hawkshaw, the fall is scarcely two inches to a mile.

III.—The *Waveney* rises at Lopham Ford near Redgrave, appearing in the area at Bungay and Beccles, beyond which it joins the Yare, south of Breydon Water. It drains an area of 339 square miles, and has a fall, below Beccles Bridge, of about two inches to a mile.

Tidal influence.—The tide flows some distance up all the rivers. According to a report by Sir John Hawkshaw, its effect is felt up the Yare as far as the New Mills at Norwich, a distance of 29 miles from the pier-head at Yarmouth. At the Foundry Bridge its range is about 15 inches. The tide is felt up the Waveney as far as Shipmeadow lock, a distance of 27 miles; and its range at Beccles Bridge, 2¾ miles below this lock, is stated to be about 14 inches. Up the Bure the tide is felt as far as Wroxham Bridge, a distance of 25 miles, and here it appears to be less than at either of the above-mentioned places, owing to the large number of broads.*

Broads.

The Broads (so named from the Anglo-Saxon *Brædan*, to broaden) form a distinct feature in East Norfolk. They are expanses of freshwater that occupy the river-valleys, sometimes in the direct course of the streams, but more often separated from them by a bank of reeds, sedges, and rushes, through which one or more narrow channels have been cut. The depth of the broads does not appear to exceed 15 feet; as a rule it is about 8 feet. In Hickling Broad the depth is for the most part sufficiently shallow to allow anyone to walk upon its gravelly bottom.

All observers agree that the broads are slowly becoming shallower, partly by the growth and decay of certain plants, partly by the deposit of earthy sediment. Mr. John Gunn has estimated this "growing-up" to take place at the rate of one foot in twenty years. (*See* p. 143.) The unembanked margins of broads

* "Norfolk News," June 14, 1879.

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and rivers, called "Ronds" or "Rands," are also apt to contract by the growth of marsh plants.

The following broads, or portions of them, are included in the area:—

		Acres.	Roods.
Bure Valley	Belaugh (and two smaller ones)	12	0
	Wroxham Bridge Broad	12	8
	Wroxham Broad	92	4
	Salhouse	22	8
	Hoveton, Great	121	5
	Hoveton, Little	57	6
	Woodbastwick Decoy	22	0
	Neatishead Burnt Fen	11	7
	Ranworth, Little	13	3
	Ranworth	117	6
	South Walsham	62	1
	Peaty Mill Dam (Pedham)		
Ant Valley	Stalham	75	6
	Barton	229	6
	Catfield	22	4
	Oliver	23	0
Hundred Stream	Womack	25	5
	Hickling and Whitesley Sound	578	0
	Chapman's	46	8
Yare Valley	Surlingham	104	0
	Strumpshaw	17	1
	Rockland	117	0
	Carlton		
	Buckenham	20	1
	Hasingham		

The areas are given, on the authority of Mr. R. B. Grantham, from a paper read before British Association at Norwich in 1868, Quart. Journ. Geol. Soc., vol. xxv., p. 258. (*See also* pp. 143, 146, and 148 of this Memoir.)

Geological Formations.

Geologically the area forms a portion of the "London Basin," for the Lower Eocene beds (proved in a deep well at Yarmouth) are no doubt united, beneath the bed of the German Ocean, with the strata exposed in East Suffolk and Essex.

The general geological structure is simple. The higher grounds are made up of the Glacial beds, and the valleys have been excavated through them so as to expose on their margins the Pliocene, or Crag formation, and the Chalk, while Alluvial deposits occupy the bottoms of the valleys.

On Plate I. (Fig. 1) is a section taken across Norwich to show the lie of the beds. The cathedral and a large part of the city from St. Augustine's Church to Pockthorpe are on River gravel and alluvium. The castle stands on a spur of the Norwich Crag Series, which further south is overlaid by brickearth and other Glacial deposits. The Market Place, Pottergate Street, &c. are directly on the Chalk; and the Crag Series is developed on the higher ground of St. Giles' Street, Grapes Hill, and Carlton Terrace. Chapel Field and Victoria Station are on Glacial brickearth, and the Norfolk and Norwich Hospital is built on Glacial sand, which extends over much of the Town Close estate. The still higher grounds of Thorpe Hamlet and Mousehold show the general succession of the beds in numerous excavations; and in the large pit above

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St. Matthew's Church (shown in Fig. 3, Plate II., from sketch made in 1877), the following beds have been opened up :—*

		Feet.
Glacial Drift	6. Sand and gravel	15
	5. Brickearth	10
Upper Crag	4. Pale grey and yellow sand and fine shingle	15
	3. Streaks of laminated clay.	
	2. False-bedded brown and yellow sand and shingle	16
	1. Chalk-with-flints	35 feet shown.

The Chalk itself has a gentle inclination (less than one degree) towards the east, and although covered unconformably by the Crag, this formation has a similar easterly dip, so that the Chalk is not exposed to the east of a line drawn from Surlingham, St. Saviour's Church, to Wroxham Bridge. To the west of this line the Chalk forms the foundation of the area; eastwards it is probable that some portions of the Eocene series may be present, although entirely concealed by the Pliocene and more recent deposits which cover the ground. Fig. 2 on Plate I. is drawn (on a natural scale) to show the inclination of the Chalk, and the probable position of the Eocene strata.

The following list includes the formations shown on the Geological Survey Map, and those proved in the area by borings:—

Recent and Post-Glacial	Alluvial Deposits	Alluvium.
		Brickearth.
		River Gravel.
Pleistocene—Glacial Drift		Gravel.
		Boulder Clay.
		Brickearth (laminated).
		Sand and Gravel.
		Brickearth.
Pliocene		Upper Crag—Norwich Crag Series (k $'_2$).
Cretaceous		Chalk (h $_5$).
		Upper Greensand (h $_4$).
		Gault (h $_3$).

The symbol k $_2'$ is engraved on the maps of the district described, to indicate the Norwich Crag. The beds grouped under the comprehensive term of Norwich Crag Series no doubt include representatives in time of the so-called "Chillesford Clay," which I have been unable to distinguish in the area. Hence one colour is generally used on the map for the Series; clays being coloured separately, in a few places, where they are of local importance. (*See* p. 34.) The Glacial gravels are coloured alike on the map, and so are the Glacial brickearths, because in some tracts there was no evidence to prove their precise position in the Glacial Drift.

No rocks older than the Cretaceous period have been proved in the area; the possibility, however, of Carboniferous rocks (including Coal-measures) being reached at a depth of about 1,200 feet is shown in the accompanying diagram, to which further reference is made in the sequel (p. 168).

* This pit has been called Underwood's Pit, Bishop's or Bishopford Bridge pit, (*see* pp. 30, 73), and has been described by Prestwich, *Quart. Journ. Geol. Soc.*, vol. xxvii., p. 469. He gave the thickness of the top gravel as 25 feet, and of the Brickearth, or "Brown Boulder-clay" beneath, as 15 feet.

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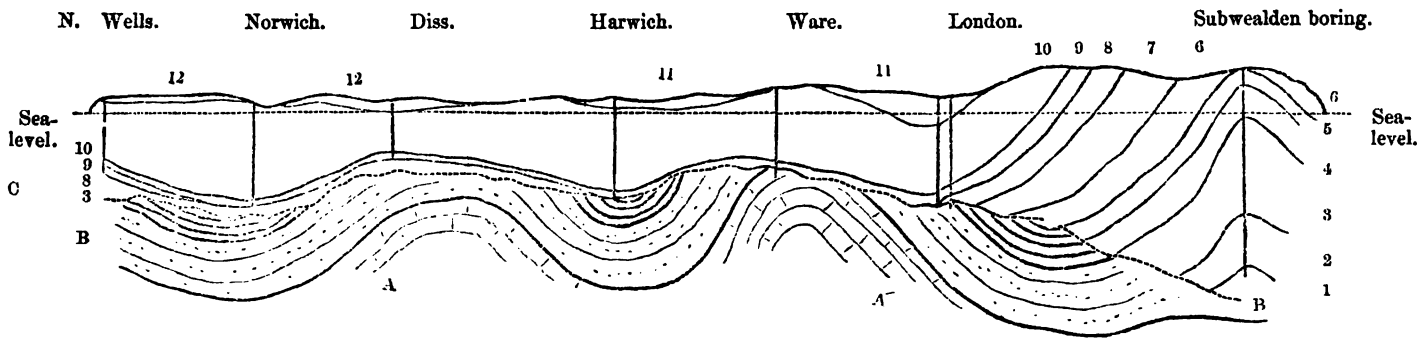
DIAGRAM TO SHOW THE POSSIBLE OCCURRENCE OF COAL MEASURES IN THE EASTERN COUNTIES.

[*From Proc. Norwich Geol. Soc., Vol. i., p.* 103.]



Longitudinal Scale—25 miles to 1 inch.

Vertical Scale—2,000 feet to 1 inch.

12. Glacial and Pliocene.
11. Eocene.
10. Chalk.
9. Upper Greensand and Gault.
8. Lower Greensand.
7. Weald Clay.
6. Hastings Beds.
5. Purbeck Beds.
4. Portland Beds.
3. Kimeridge Clay.
2. Corallian.
1. Oxford Clay.

C. Carboniferous (shown in basins with thick lines).
B. Devonian and Old Red Sandstone.
A. Silurian.

N.B.—The vertical lines indicate borings and wells.

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CHAPTER II.—CRETACEOUS.

Gault.

This formation was met with in the Carrow boring, Norwich, at a depth of about 1,170 feet below the surface.* It consisted of blue clay, and was proved to a thickness of 36 feet.

The following fossils were obtained from it by the Rev. J. Crompton† :—

MOLLUSCA.

Ammonites lautus, Sby.
———— symmetricus, Sby.
Belemnites minimus, List.
Inoceramus sulcatus, Park.

BRYOZOA.

(Fragments.)

FORAMINIFERA.

[Named by Mr. F. Kitton.]

Dentalina (not uncommon).
Entosalenia (rare).
Frondicularia (rare).
Globigerina (common).
Lagena (rare).
Nodosaria (not uncommon).
Orbulina (common).
Polymorphina (not uncommon).
Rotalina (not uncommon).
Textularia (common).

Mention is made in the MS. Section-book of Wells in the Geological Survey Office, of "Lower Greensand" being reached in the Carrow boring, but no details of the formation are given.

Upper Greensand.

A bed referred to the Upper Greensand was met with at a depth of from 1,164 to 1,170 feet below the surface, in the boring at Carrow. According to the observations of C. B. Rose it was "found to possess the mineralogical character of that stratum in "Wiltshire, and to have a thickness from 6 to 8 feet."‡ Thus it consisted of chert and sands with glauconitic grains. The only fossil obtained is a Sponge detected by Mr. F. Kitton in a piece of the chert, and named *Lithospongitis Kittonii* by Mr. H. J. Carter.§

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* The depth at which the beds were reached in this boring are given with some doubt, as the accounts obtained by different individuals vary. *See* pp. 163, 164.

† Geologist, vol. v., p. 461; *see also* C. B. Rose, Proc. Geol. Assoc., vol. i., p. 226; Geol. Mag., vol. iv., p. 31.

‡ Proc. Geol. Assoc., vol. i., p. 226.

§ Ann. Nat. Hist., ser. 4, vol. ii., 1873, pp. 439, 443; *see also* Kitton, Trans. Norf. and Norwich Nat. Soc., vol. i., p. 81.

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Chalk.

General Remarks.

The Chalk in the neighbourhood of Norwich consists of soft white earthy limestone, usually much fissured and fractured. It is made up of numerous beds which sometimes attain a thickness of 18 inches, and are usually wedge-shaped masses tapering in different directions. These divisional lines seem to be due to a kind of horizontal jointing rather than to any direct process of deposition. Layers of interrupted flint nodules occur at irregular intervals, which correspond with the general direction of the bedding, and mark in a rough way the stratification of the Chalk. Among the flints, the huge forms termed "Paramoudras" or potstones are often conspicuous.

The Chalk exposed at Norwich belongs to the uppermost division of the English Chalk. Its characteristic fossils, according to the late Dr. S. P. Woodward, are *Chama inæquirostrata, Ostrea larva, Pecten concentricus, Magas pumilus, Rhynchonella plicatilis*, var. *octoplicata, Terebratula gracilis, Trigonosemus* (*Terebratella*) *elegans.** The more abundant fossils include the "Thunderbolts," *Belemnitella mucronata*, and *B. minima;* the "Fairy" or "Sugar Loaves," *Ananchytes ovatus;* the "Heart," *Cardiaster granulosus;* the oyster *Ostrea vesicularis;* the lamp-shell *Terebratula carnea*, and numerous teeth of Fishes.

Fossils may be obtained at any of the pits now worked, such as those between Catton and Thorpe Hamlet, at Thorpe Lime Kiln, Whitlingham, Trowse, Hartford Bridge, Stone Hills on the Dereham Road, &c. Many specimens were formerly obtained from a pit on the south side of West Pottergate Street, Norwich, and from one situated on the south side of St. Giles' Road, near the City Gaol. Mr. R. Fitch tells me that the latter was known to collectors as "the Baculite pit," from the fact that Baculites were obtained there. *Ostrea* was also abundant. He has also procured many Corals at this pit, and also at Stoke Holy Cross. Fossils may likewise be obtained at Coltishall, in the Bure Valley.

The Chalk of Norwich has sometimes been thought to include higher beds than are found elsewhere in England, and Dr. Duncan has inclined to this view, observing that "the Coral evidence "brings the Norfolk Chalk closer in relation with the Faxoe, "Rugen, and Ciply deposits."† (*See* p. 20.)

The lacertian reptile *Mosasaurus* has, under the subgeneric name of *Leiodon anceps*, been recognised from several pits near Norwich. Mr. T. G. Bayfield has recorded the discovery of a large number of its bones and teeth at the Lollard's Pit, near Bishop's Bridge, Norwich.‡

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* Geologist, vol. vi., p. 154.
† Supp. to Fossil Corals (Palæontograph Soc.).
‡ Geol. Mag., vol. i., p. 296.

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The thickness of the Chalk at Carrow was proved by the deep well to be as much as 1,152 feet. To this at least 35 feet must be added to give the total thickness of the Chalk at Norwich, inasmuch as it rises to at least this height above the river-level near Mousehold. Mr. Rose indeed allowed 40 feet for Chalk above the level of that touched at the Carrow boring, thus estimating its total thickness at 1,192 feet.* (*See* p. 163.)

As before mentioned, the Chalk has a gentle inclination to the east, which may be estimated at about 27 feet to a mile (less than 1°) if taken in connexion with the Yarmouth boring, although this estimate is at best very vague, as the upper surface of the Chalk may have suffered much and irregular denudation. (*See* fig. 2, Plate I.) Between Hunstanton and Norwich the base of the Chalk shows an inclination of about 48 feet in a mile.†

The fissured and sometimes rubbly surface of the Chalk is to a large extent caused by rain and frost, but occasionally the Chalk has undergone disturbance by some more powerful agent, so that the mass of the rock is broken up, and in part re-arranged, the flint layers are disrupted, and all symptoms of stratification destroyed. Thus in a pit at Costessey the flints were disturbed to a depth of 20 feet. The Chalk when in this condition is known as "Glaciated Chalk," and to this reference will subsequently be made.

The surface of the Chalk frequently exhibits great hollows or channels filled with material from the superincumbent deposit. These hollows called "pipes" or "sand-galls" are caused by the erosion of the Chalk, and are sometimes suddenly filled by the sand or gravel, causing subsidence of the ground; hence the Chalk is an uncertain foundation for buildings (*see* p. 138).

Only on the slopes of the valleys is the Chalk exposed in the area. In the Bure Valley it appears as an extensive inlier between Aylsham and Wroxham, and it does not come to the surface east of the railway bridge at the latter place. In the grounds of Woodbastwick Hall there is a large and deep pit, now entirely overgrown, which may have been opened down to the Chalk.

In the Yare Valley the Chalk does not extend further east than Postwick and Surlingham. Southwards, in the Tese Valley, it is well shown at Stoke Holy Cross, and may be traced as far as All Saints Church, Shottesham, in the bed of the stream. Below Tasburgh Camp the actual extent of the Chalk at the surface is not readily to be traced. It is to be seen at Tharston Furze Hill, and in a pit south of Flordon church; still further south I observed traces of it in the banks of the stream and in ditch cuttings in the parishes of St. Mary and St. Peter, Forncett.

In the city of Norwich, Chalk has been exposed at the junction of London Street with the "Back of the Inns," at Gurney's Bank, in Pottergate Street, &c.

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* Proc. Geol. Assoc., vol. i., p. 226.
† Whitaker, Proc. Norwich Geol. Soc., vol. i., p. 17.

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Fossils.

Since the year 1833, when the "Outline of the Geology of Norfolk" by Samuel Woodward was published, no attempt at a full list of the fossils from the Chalk of Norfolk has been made. The accompanying list is intended to supply the deficiency, so far at least as concerns the Upper Chalk of the neighbourhood of Norwich.

In compiling it all localities given by S. Woodward (S. W.) are included, and the following authorities have also been consulted: The works of the Palæontographical Society and the Monographs by Darwin, Davidson, Duncan, Edwards and Haime, Rupert Jones, Owen, Sharpe, and Wright; the works of Toulmin Smith, Morris, and Barrois; the Decades of the Geological Survey, and the Catalogue of Cretaceous Fossils in the Museum of Practical Geology.

The following collections were specially examined by Mr. Etheridge, and the species recorded from them are given on his authority: The collections of Mr. Robert Fitch (R. F.), and of the late John King (J. K.), of Norwich; and the specimens in the Norwich Museum (N. M.), many of which originally formed part of the collection of the late S. Woodward. The specimens collected by myself during the course of the Geological Survey, as well as a few Chalk fossils from Norwich, previously in the Museum of Practical Geology, all of which are marked (M. P. G.), were identified by Mr. Etheridge and Mr. George Sharman.

Of other collections, not examined by Mr. Etheridge, may be mentioned that of Mr. T. G. Bayfield, of Norwich, now in the British Museum (T. G. B.), and that of the Geological Society of London (G. S. L.). A few species are given on the authority of Dr. S. P. Woodward (S. P. W.), and some on the authority of Dr. J. E. Taylor (J. E. T.), whose specimens are placed in the Ipswich Museum.

For the convenience of students I have given the synonyms published in S. Woodward's Geology of Norfolk, and references to some of the published figures of the species.*

The list of Fishes was corrected by Mr. E. T. Newton, and the list has throughout been revised by Mr. Etheridge, F.R.S.

List of Fossils from the Upper Chalk of the Neighbourhood of Norwich.

[*See also* List of Fossils from Flint-gravel, p. 26.]

Spongida.		
Brachiolites Fittoni, *Mant.* -	Millepora Fittoni, Geol. Suss., t. 15, f. 10.	Bishop's Bridge (S.W.).
Cliona cretacea, *Portl.* -	Clionites Conybearei, Morris, Ann. N. H., 1851, t. 4, f. 8.	Norwich (M.P.G., G.S.L.).
—— glomerata, *Morris* -	Morris, Ann. N. H., 1851, t. 4, f. 11.	Norwich.
Coeloptychium agaricoides, *Goldf.*	Geol. Norf., Tab. 4, f. 19 -	Hartford Bridge (S.W., J.K.), Stoke Holy Cross, Thorpe (M.P.G.).
Coscinopora globularis, *D'Orb.*	Millepora globularis, Geol. Norf., Tab. 4, f. 10-12.	Norwich (S.W.).

* The full titles of most of the works in which these figures are published will be found in the Appendix.

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Coscinopora ? - - -	- - - - - -	Hartford Bridge, Thorpe, Belaugh (M.P.G.).
Guettardia angularis, *T. Smith*	Brachiolites angularis; Ventriculites quadrangularis, Mant., Geol. Suss., t. 15, f. 6.	Norwich (N.M.).
Scyphia ? cribrosa, *Röm.* -	Spongia cribrosa, Phillips, Geol. Yorks., t. 1, f. 7.	Catton (S.W.).
Spongia lobata, *Park.* -	Org. Rem., ii., t. 7, f. 6 -	Catton (S.W.).
——— ramosa, *Mant.* -	Geol. Suss., t. 15, f. 11 -	Catton (S.W.).
Talpina* dendrina, *Quenst.* -	Morris, Ann. N. H., 1851, t. 4, f. 6 b, 7.	Norwich.
——— ramosa, *Hagenow* -	Morris, Ann. N. H., 1851, t. 4, f. 4.	Norwich.
——— solitaria, *Hagenow* -	Morris, Ann. N. H., 1851, t. 4, f. 6a.	Norwich.
Ventriculites alternans, *Röm.* -	Scyphia alternans, Kreide, t. 3, f. 9.†	Thorpe (M.P.G.).
——— decurrens, *T. Smith*	Ann. N. H., 1848, t. 13, f. 8 -	Norwich (J.K.).
——— infundibuliformis, *Woodw.*	Geol. Norf., Tab. 4, f. 20, 21	Catton, Hartford Bridge (S.W.).
——— quincuncialis, *T. Smith.*	V. alcyonoides; Smith, Ann. N. H., 1848, p. 207.	Thorpe (J.K.).
——— radiatus, *Mant.* -	Geol. Suss., Tab. 10-13.	Catton, Hartford Bridge (S.W.), Thorpe, Heigham (J.K.)

The following species have been determined by Dr. G. J. Hinde (Fossil Sponge Spicules from the Upper Chalk. Munich, 1880) from the interior of a flint which he found at Horstead:—*Caminus ?*, *Carterella*, sp., *Coscinopora*, *Craticularia*, *Cytispongia*, *Geodia ? clavata*, Hinde, *G. ? coronata*, Hinde, *G. ? Wrightii*, Hinde, *Hyalostelia fusiformis*, Hinde, *Leptophragma*, *Lyidium Zitteli*, Hinde, *L. cretacea*, Hinde, *Ophiraphidites*, *Pachastrella Carteri*, Hinde, *P. primæva ?*, *Plinthosella squamosa*, Zittel, *Racodiscula*, *Ragadinia annulata*, Hinde, *Reniera*, *Scolioraphis ?*, *Stauractinella cretacea*, Hinde, *Stelletta ?*, *Tethya ?*, *Tisiphonia ?*, *Ventriculites ?*.

RHIZOPODA.

Foraminifera.

Bulimina - - -	- - - - - -	Norwich (T.R.J.).
Dentalina - - -	- - - - - -	Norwich (T.R.J.).
Flabellina pulchra, *D'Orb.* -	M. G. S. Fr., vol. iv., t. 2, f. 12-14.	Norwich (T.R.J.).
Frondicularia striatula, *Reuss* -	Böhm. Kreide, 2, t. 8, & 23, t. 43, f. 11.‡	Norwich (Morris).
Globigerina - - -	- - - - - -	Carrow (F. Kitton).
Planorbulina ammonoides, *Reuss*	Ann. N. H., ix., 1872; Geol., vi., t. 15.	Thorpe (Jones & Parker).
——— Haidingerii, *D'Orb.*	Ann. N. H., ix., 1872 -	Thorpe (Jones & Parker).
——— lobatula, *W. & J.*	Truncatulina, Ann. N. H., ix., 1872.	Thorpe (Jones & Parker).
——— Ungeriana, *D'Orb.*	Ann. Nat. H., ix., 1872 -	Thorpe (Jones & Parker).
Rotalia umbilicata, *D'Orb.* -	Mem. Soc. Geol. Fr., iv., t. 8, f. 4-6; Ann. N. H., ix., 1872. Rotalina.	Thorpe (Jones & Parker).
——— sp. - - -	- - - - - -	Carrow (F. Kitton).
Textularia - - -	- - - - - -	Carrow (F. Kitton), Norwich (T.R.J.).
Tinoporus concavus, *Lamk.* -	T. globularis, Phil. Orbitolina.	Thorpe (Jones & Parker).

ACTINOZOA.

Caryophyllia cylindracea, *Reuss*	Cyathina, Caryophyllia lævigata; Parasmilia, Monocarya cultrata; Dixon, Foss. Suss., t. 18, f. 11, 13. Br. Foss. Cor., Pal. Soc., t. 9, f. 1a-d. Duncan, Sup. to Br. Foss. Cor., t. 1, f. 7-12.	Norwich (R.F.).

* It has not been determined whether these are Boring Sponges or Annelides.
† Römer, F. A. Die Versteinerungen des norddeutschen Kreidegebirges, 1840-41.
‡ Reuss, A. E. Die Versteinerungen der böhmischen Kreideformation 1845-46.

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Diblasus Gravensis, *Lons.* -	Dixon, Foss. Suss., t. 18, f. 14; Duncan, *op. cit.*, t. 2, f. 1-11.	Hartford Bridge, Thorpe (J.K.).
Parasmilia centralis, *Mant.* -	Caryophyllia centralis, Geol. Suss., t. 16, f. 2; Edwards and Haime, Br. Foss. Cor., Pal. Soc., t. 8, f. 1a-c.	Hartford Bridge, Coltishall (S.W.), Trowse (S.W., M.P.G.), Postwick (J.K.), Whitlingham, Hartford Bridge (M.P.G.), Norwich (R.F.).
——— cylindrica, *Edw.* -	Br. Foss. Cor., t. 8, f. 5 -	Norwich (Morris).
——— Fittoni, *Edw.* -	Br. Foss. Cor., t. 9, f. 5 -	Norwich (J.K.).
Trochosmilia cylindrica, *Duncan.*	t. 5, f. 1-3 - - -	Hartford Bridge (J.K.).
——— granulata, *Duncan.*	t. 4, f. 1-4; t. 6, f. 9 - -	Norwich.
——— laxa, *Edw. & Haime.*	Cœlosmilia laxa, Edw., Br. Foss. Cor., t. 8, f. 4. Duncan, t. 3, f. 11-17; t. 4, f. 9-12.	Norwich (T.G.B.).
——— Wiltshiri, *Duncan.*	Cœlosmilia, t. 4, f. 5-8 -	Norwich.

MOLLUSCOIDA.

Polyzoa.

Alecto gracilis, *Edw.* - -	Alecto, sp., Woodw., Geol. Norf., Tab. 4, fig. 16.	Norwich (S.W., Morris).
Ceriopora polymorpha, *Goldf.* -	Millepora polymorpha ?, Woodw., Geol. Norf., Tab. 4, fig. 13. ? M. gracilis (Woodw.), Geol. Norf., Tab. 4, fig. 15.	Catton and St. Giles', Norwich, common (S.W.).
Diastopora gracilis, *Edw.* -	? Flustra tubulosa, Woodw., Geol. Norf., Tab. 4, fig. 5.	Common on Ananchytes (S.W.).
Discopora ? mammillata, *Woodw.*	Geol. Norf., Tab. 4, fig. 2 -	On Ananchytes, rare (S.W.).
——— ? radiata, *Woodw.* -	Geol. Norf., Tab. 4, fig. 3 -	On Ananchytes, rare (S.W.).
Flustra quadrata, *Woodw.* -	Geol. Norf., Tab. 1, fig. 3 -	Whitlingham, rare (S.W.).
——— reteformis, *Woodw.* -	Geol. Norf., Tab. 4, fig. 6 -	Common on Ananchytes (S.W.).
——— tessclata, *Woodw.* -	Geol. Norf., Tab. 4, fig. 4 -	Common on Ananchytes (S.W.).
——— utricularis, *Woodw.* -	Geol. Norf., Tab. 4, fig. 7 -	Common on Ananchytes (S.W.).
Holostoma contingens, *Lons.* -	Dixon, Foss. Suss., t. 18A, f. 9.	Norwich (J.K.).
Idmonea ? truncata, *Blainv.* -	Millepora truncata ?, Geol. Norf., Tab. 4, fig. 14.	Norwich (S.W.).

Brachiopoda.

Crania Ignabergensis, *Retz* -	C. striata, Geol. Norf., Tab. 6, fig. 15; C. ovalis, Geol. Norf., Tab. 6, fig. 16; Davidson, Mon. Brac., Pal. Soc., 2, Tab. 1, f. 8-14	Norwich, Eaton (S.W., *MS.*), Hartford Bridge, rare (S.W.), (T.G.B.).
——— Parisiensis, *Defr.* -	Davidson, Mon. Brac. 2, t. 1, f. 1-7.	Norwich (Nor. Mus. R.E.), Thorpe (J.K.).
Kingena lima, *Defr.* - -	Terebratula pentangulata, Geol. Norf., Tab. 6, fig. 10; Davidson, t. 4, f. 15-28, t. 5, f. 1-4.	Norwich, Hartford Bridge (S.W.).
Magas pumilus, *Sby.* - -	M. truncata, Geol. Norf., Tab. 6, fig. 9; M. magna; M. punctata; Davidson, Mon. Brac. 2, t. 2, f. 1-12, 33.	Norwich, rare (S.W.), Catton, rare (S.W.), (T.G.B.).
Rhynchonella Cuvieri, *D'Orb.*	Davidson, t. 10, f. 50-54 -	Norwich (T. Dav.).
——— limbata, *Schl.* -	Terebratula lentiformis, Geol. Norf., Tab. 6, fig. 11; T. subplicata; Davidson, t. 12, f. 1-5.	Norwich (S.W.), Hartford Bridge, Earlham, Costessey, Thorpe, Trowse, Whitlingham (M.P.G.).

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Rhynchonella Mantelliana, *Sby.*	Davidson, Mon. Brac., Pal. Soc., 2, t. 12, f. 20–23.	Norwich (J.K.).
——— plicatilis, *Sby.* -	Terebratula plicatilis, Davidson, t. 10, f. 37–42.	Norwich (S.W.), Trowse, Hartford Bridge, Earlham, Thorpe, St. James' Pit, Catton (M.P.G.).
——— ——— var. octoplicata, *Sby.*	Terebratula octoplicata, Davidson, t. 10, f. 1–17.	Norwich (S.W.), Bishop's Bridge (T.G.B.), Trowse, Catton, Stoke Holy Cross (M.P.G.).
——— ——— var. Woodwardi, *Dav.*	Terebratula Gallina, Geol. Norf., Tab. 6, fig. 12; Davidson, t. 10, f. 43–46.	Norwich, Costessey (T.G.B.), Hartford Bridge, common (S.W.).
Terebratula* carnea, *Sby.* -	T. elongata; Davidson, Mon. Brac. 2, t. 8, f. 1–5.	Norwich, Trowse (M.P.G., S.W.), Hartford Bridge (S.W.), Belaugh, St. James' Pit, Catton, Whitlingham, Bishop's Bridge, Thorpe (M.P.G.).
——— biplicata, *Sby.* -	Davidson, t. 6, f. 1–42; Sup., t. 5, f. 1, 2.	Hartford Bridge, Earlham, Bishop's Bridge, St. James' Pit, Belaugh (M.P.G.).
——— obesa, *Sby.* -	Davidson, Mon. Brac. 2, t. 5, f. 13–15, 16? (*see* Sup.).	Norwich (coll. R. Fitch), Bishop's Bridge, rare (S.W.), Thorpe (J.K.).
——— semiglobosa, *Sby.*	T. subundata, T. subrotunda; Davidson, Mon. Brac. 2, t. 8, f. 6–18.	Bishop's Bridge, common, Hartford Bridge (M.P.G., S.W.), Trowse, Whitlingham, Earlham, Thorpe (M.P.G.).
Terebratulina gracilis, *Schl.* -	Terebratula rigida; Davidson, Mon. Brac. 2, t. 2, f. 13–15 (*see* Sup.).	Norwich.
——— striata, *Wahl.* -	T. Gervillei, Geol. Norf., Tab. 6, fig. 14; T. striatula; Davidson, Mon. Brac. 2, t. 2, f. 18–25, 27, 28? (*see* Sup.).	Norwich (rare) on flints (S.W.), Trowse, Postwick (S.W., *MS.*), St. James' Pit (common) (J.E.T.), Magdalen Chapel, rare (S.W.), Hartford Bridge (J.K.).
Trigonosemus elegans, *Koenig* -	Terebratella, Davidson, Mon. Brac. 2, t. 4, f. 1–4.	Norwich (R.F.).

MOLLUSCA.

Lamellibranchiata.

Anomia? - - -	- - - - - -	Norwich (N.M.).
Arca Marullensis, *D'Orb.* -	Byssoarca, Pal. Fran., Ter. Cret. iii., p. 205, t. 310, f. 3–5.	Catton (T.G.B.).
—— sp. - - -	- - - - - -	Norwich (R.F.).
Chama inæquirostrata, *Woodw.*	Diceras, Geol. Norf., t. 5, f. 22.	Norwich (M.P.G.), Hartford Bridge, St. Giles Gate, Trowse (S.W.), Thorpe, Postwick (J.K.).
Crepidula? - - -	- - - - - -	Norwich (T.G.B.).
Dianchora lata, *Sby.* - -	Dixon, Foss. Suss., t. 28 f. 30.	Hartford Bridge (S.W., J.K.).
——— striata, *Sby.* -	Min. Con., t. 80, f. 1 - -	Norwich (N.M.).

* T. obliqua of S. Woodward is not Cretaceous (Davidson).

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Exogyra - - -	- - - - -	Norwich (J.K.).
Gryphæa - - -	- - - - -	Thorpe (M.P.G.).
Inoceramus concentricus, *Park*	Geol. Trans. 5, t. 1, f. 4 -	Catton (T.G.B.).
——— digitatus, *Sby.* -	Min. Con., t. 604 - -	Hartford Bridge (S.W.).
——— giganteus, *S. Woodw.*	(Not figured) - -	Trowse, Bishop's Bridge (S.W.).
——— Lamarckii, *Park* -	Dixon, Foss. Suss., t. 28, f. 29.	Sprowston (J.K.).
——— latus, *Mant.* -	Geol. Suss., t. 27, f. 10 -	Norwich (S.W.).
——— striatus, *Mant.* -	Geol. Suss., t. 27, f. 5 -	Hartford Bridge (S.W.), Tharston (M.P.G.).
Leda ? pulchra, *Sby.* - -	Dixon, Foss. Suss., t. 28, f. 10.	Catton (T.G.B.).
Lima æqualis, *Héb.* - -	Spondylus - - -	Norwich (C. Barrois).
—— Brightoniensis, *Mant.* -	Plagiostoma, Spondylus; Geol. Suss., t. 25, f. 15.	Hartford Bridge (S.W.).
—— granosa, *Sby.* - -	Dixon, Foss. Suss., t. 28, f. 24.	Norwich (M.P.G., G.S.L.).
—— granulosum, *S. Woodw.* -	Plagiostoma; Geol. Norf., t. 5, f. 26.	Hartford Bridge (S.W.).
—— Hoperi, *Sby.* - -	Plagiostoma, Min. Con., t. 280.	Hartford Bridge (S.W.), Thorpe (J.K.), St. James Pit ? (M.P.G.).
—— parallela, *Sby.* - -	Min. Con., t. 9 - -	Norwich (J.K.).
—— spinosa, *Sby.* - -	Spondylus, Plagiostoma, Dianchora; Min. Con., t. 78; Geol. Norf., Tab. 5, f. 25.	Norwich, Hartford Bridge (SW., R.F., M.P.G.), Bishop's Bridge (T.G.B.), Thorpe (J.K.), Trowse, Tharston ? (M.P.G.).
Modiola quadrata, *Sby.* -	M. elegans ? S. Woodward; Dixon, Foss. Suss., t. 28, f. 13.	St. Giles' Gate (S.W.), Norwich (J.K.), Stoke Holy Cross (N.M.), Catton (T.G.B.).
Nucula - - - -	(Leda ?) - - -	St. Giles' Gate (R.F.).
Ostrea concentrica, *S. Woodw.*	Geol. Norf., t. 6, f. 5 -	Hartford Bridge (S.W.).
——— flabelliformis, *Nilss.** -	Pet. Suec., t. 6, f. 4 - -	Norwich (M.P.G., G.S.L.), Trowse ? (*O. frons* ? M.P.G.).
——— frons, *Park.* - -	Org. Rem. 3, t. 15, f. 4 -	Norwich (J.K.).
——— inæquicostata, *S. Woodw.*	Geol. Norf., t. 6, f. 4 -	Hartford Bridge (S.W.).
——— larva, *Lam.* - -	O. canaliculata, Min. Con., t. 135, f. 1. O. lunata.	Norwich (S.P.W.)
——— Normaniana, *D'Orb.*† -	Pal. Fr., Ter. Crét., t. 488, f. 1.	Trowse, Hartford Bridge (M.P.G.).
——— semiplana, *Mant.* -	O. alæformis, Geol. Norf., t. 6, f. 1-3.	Norwich, Hartford Bridge (S.W.).
——— triangularis, *S. Woodw.*	Geol. Norf., t. 6, f. 6, 7 -	Hartford Bridge (S.W.), St. James' Pit ? (M.P.G.).
——— vesicularis, *Lam.* -	Gryphæa globosa, Sby., Min. Con., t. 392.	Norwich, Hartford Bridge (S.W., M.P.G.), Sprowston (J.K.), Trowse, Whitlingham, Thorpe, St. James' Pit, Catton (M.P.G.).
Pecten Beaveri, *Sby.* - -	Min. Con., t. 158 - -	Norwich (S.W.).
——— concentricus, *S. Woodw.*	Geol. Norf., t. 5, f. 27, 28 -	Hartford Bridge (S.W., M.P.G.), Thorpe (J.K.).
——— var. Mantelliana, *D'Orb.*	Ter. Crét., t. 440, f. 8-11 -	Hartford Bridge (M.P.G.).
——— elongatus, *Lam.* -	D'Orb., Ter. Crét., t. 436, f. 1-4.	Norwich (J.K.).
——— nitidus, *Mant.* - -	Geol. Suss., t. 26, f. 4, 9. P. cretosus.	Hartford Bridge (S.W., M.P.G.), Bishop's Bridge, Trowse, Earlham (M.P.G.).

* Nilsson, S. Petrificata Suecana formationis Cretaceæ descripta et iconibus illustrata, 1827.
† D'Orbigny, A. Paléontologie Française. Terrain Crétacé.

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Pecten orbicularis, *Mant.*	Geol. Suss., t. 26, f. 8	Norwich (R.F.).
——— quinquecostatus, *Sby.*	Geol. Suss., t. 25, f. 10; t. 26, f. 20.	Norwich (J.K.), Trowse, Bishop's Bridge, St. James' Pit (M.P.G.), Eaton (J.E.T.).
——— sexcostatus, *S. Woodw.*	Geol. Norf., t. 5, f. 29	Hartford Bridge, Bishop's Bridge (S.W.).
Pholadomya decussata, *Phil.*	Geol. Yorks, 1, t. 2, f. 9	Norwich (N.M.), Catton (T.G.B.), Sprowston (J.K.), Bishop's Bridge (R.F.).
——— sp.	- - - - -	Postwick (J.K.).
Pinna sulcata, *S. Woodw.*	Geol. Norf., t. 5, f. 23	St. Giles' Gate (S.W.).
——— tetragona? *Sby.*	Min. Con., t. 313, f. 1	Norwich (J.K.).
——— sp.	- - - - -	Catton (T.G.B.).
Plicatula sigillina, *S. P. Woodw.*	Geol. Mag., vol. i., t. 5, f. 1-5	Norwich (G.S.L.).
Spondylus complanatus, *D'Orb.*	Ter. Crét., t. 451, f. 7-10	St. James' Pit (M.P.G.).
——— Dutemplianus, *D'Orb.*	Ter. Crét., t. 460, f. 6-11	Trowse (M.P.G.).
	Gasteropoda.	
Avellana Cassis, *D'Orb.*	Cassis Avellana, D'Orb. Ter. Crét., t. 169, f. 10-13.	Norwich (S.W.), Stoke Holy Cross (R.F.), Bishop's Br. (T.G.B.).
Dentalium	- - - - -	Bishop's Bridge (T.G.B.).
Dolium?	- - - - -	Hartford Bridge (N.M.), Bishop's Bridge (R.F.).
Natica	- - - - -	Thorpe (J.K.).
Nerinæa unicarinata, *S. Woodw.*	Cerithium, Geol. Norf., t. 6, f. 21.	Hartford Bridge (S.W., N.M.), Thorpe (J.K.).
Patella?	- - - - -	Hartford Bridge (S.W.).
Pleurotomaria perspectiva, *Mant.*	Cirrus depressus, Trochus linearis; Min. Con., t. 428, f. 1, 2, Geol. Suss., t. 18, f. 12, 16, 18; ? C. striatus, Geol. Norf., t. 6, f. 20.*	Hartford Bridge (S.W.), Trowse (J.K.).
Solarium	- - - - -	Catton (T.G.B.).
Trochus Basteroti, *Brongn.*	Geol. Norf., t. 6, f. 19	Hartford Bridge (S.W.).
Turritella	- - - - -	Thorpe (J.K.).
	Cephalopoda.	
Ammonites Catinus, *Mant.*	Geol. Suss., t. 22, f. 10; Sharpe, Chalk Moll., Pal. Soc., t. 13, f. 1.	Norwich, St. Giles' Gates, unique (S.W.)
——— Icenicus, *Sharpe*	t. 19, f. 4 - - -	Hartford Bridge (J.K.).
——— Lewesiensis, *Sby.*	Min. Con., t. 358; Sharpe, t. 21, f. 1.	Hartford Bridge (J.K.).
——— peramplus, *Mant.*	Sharpe, t. 10, f. 1-3 - -	Norwich (T.G.B.).
——— Portlocki, *Sharpe*	Ch. Moll., t. 13, f. 2, 3	Hartford Bridge (J.K.).
——— Velledæ, *Mich.*	Sharpe, t. 17, f. 7; t. 19, f. 6	Norwich (C. Barrois).
——— Jukesii? *Sharpe*	t. 23, f. 11 *a-c* - -	Norwich (T.G.B.).
Aptychus Gollevillensis, *Sharpe*	t. 24, f. 5 - - -	Norwich (T.G.B.).
——— Icenicus, *Sharpe*	t. 24, f. 7 *a-b* - -	Norwich (T.G.B.).
——— peramplus, *Sharpe*	A. crassus, Héb.; Sharpe, t. 25, f. 10 *ab.*	Norwich.
——— Portlocki, *Sharpe*	A. obtusus, Héb.; Sharpe, t. 25, f. 2-4, 6?	Norwich (T.G.B.).
——— rugosus, *Sharpe*	A. insignis, Héb.; Sharpe, t. 24, f. 8 *ab*, 9.	Norwich (J.K., T.G.B.).
Baculites Faujasii, *Sby.*	Dixon, Foss. Suss., t. 27	Bishop's Bridge, Catton, rare (S.W.), St. Giles' Gate (R.F.).
Belemnitella lanceolata, *Schlt.*	Actinocamax, Belemnites mucronatus; Sharpe, Ch. Moll., t. 1, f. 4-6.	Norwich, &c., abundant (S.W.).
——— mucronata, *Schlt.*	Belemnites electrinus; Sharpe, Ch. Moll. 6, t. 1, f. 1-3.	Norwich, &c., abundant (S.W.), Thorpe Hamlet (J.K.), Hartford Bridge, Earlham, Costessey, St. James' Hill, Catton (M.P.G.).

* This may be *Turbo gemmatus*, Sby. (R. Etheridge.)

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Belemnitella plena? *Blainv.* -	Sharpe, Ch. Moll., Pal. Soc., 9, t. 1, f. 12–16.	Trowse, Hartford Bridge, Costessey, St. Jas' Hill (M.P.G.).
Hamites armatus, *Sby.* -	H. plicatilis; Mantell, Geol. Suss., t. 16, f. 5; t. 23, f. 1, 2.	St. Giles', Norwich, Hartford Bridge, rare (S.W.).
——— ? ellipticus, *Mant.* -	Geol. Suss., t. 23, f. 9 -	Catton (S.W., fragment).
——— sp. - - -	- - - - -	St. Giles' (S.W.), Thorpe (J.K.).
Nautilus elegans, *Sby.* - -	Sharpe, Ch. Moll. 12, t. 3, f. 3; t. 4, f. 1.	Thorpe (J.K.).
——— Deslongchampsianus, *D'Orb.*	Sharpe, Ch. Moll., t. 3, f. 1, 2	Norwich (N.M., T.G.B.), Hartford Bridge (J.K.).
——— sp. - - -	- - - - -	Catton (J.K.).
——— radiatus, *Sby.*? or pseudo-elegans, *D'Orb.*?	- - - - -	St. James' Hill (M.P.G.).
Turrilites costatus, *Lam.* -	Mantell, Geol. Suss., t. 23, f. 15; t. 24, f. 1, 4, 5; Sharpe, t. 27, f. 1–5, 15, 16.	Hartford Bridge, rare (S.W.).
——— sp. allied to polyplocus, *Roem.*	- - - - -	St. James' Hill (M.P.G.).

ECHINODERMATA.

Echinoidea.

Ananchytes lævis, *Deluc* -	Holaster; Ag. Ech. Suis. 1, t. 3, f. 1–3.*	Norwich (M.P.G., G.S.L.).
——— ovatus, *Leske* -	Holaster, Echinocorys, Galea, A. hemispherica, A. pustulosa; Forbes, Mem. Geol. Surv., Dec. 4, t. 6.	Norwich, Hartford Br. (S.W., M.P.G.), Thorpe, Catton, Sprowston (M.P.G., J.K.), Costessey, Whitlingham, Earlham, Drayton, Stoke Holy Cross, Newton Flotman (M.P.G.).
——— planus, *Mant.* -	Spatangus, Geol. Suss., t. 17, f. 9.	Norwich (M.P.G., G.S.L.).
Bourgeticrinus cylindricus, *McCoy.*	Ann. N. H., 1848, p. 404 -	Norwich (Morris).
——— ellipticus, *Miller*	Apiocrinites; Dixon, Foss. Suss., t. 20.	Bishop's Bridge (S.W.), Norwich (J.E.T.).
——— Milleri, *McCoy* -	Ann. N. H., 1848, p. 405 -	Norwich (Morris).
Cardiaster excentricus, *Rose*† -	Spatangus, Geol. Norf., t. 1, f. 5; Forbes, Mem. Geol. Surv., Dec. 4, t. 10. Wright, t. 70, f. 1 *a–k*.	Hartford Bridge (S.W.).
——— grandis, *Benett* -	Cat. Wilts Foss., p. 7; S.P.W., Appendix, Dec. 5, Mem. Geol. Survey.	Norwich (J.K.).
——— granulosus, *Goldf.* -	Holaster æqualis: Spatangus cordiformis, Geol. Norf., t. 5, f. 6; Forbes, Mem. Geol. Surv., Dec. 4, t. 9. C. ananchytis; Wright, Cret. Ech. Pal. Soc., t. 69, f. 2 *a–i*, 3.	Norwich, Carrow (Rev. J. Crompton), Hartford Bridge (S.W., M.P.G.), Catton (T.G.B., M.P.G.), Thorpe (J.K.).
——— pilula, *Lam.* -	Holaster; Forbes, Mem. Geol. Surv., Dec. 4, t. 8.	Norwich (M.P.G., G.S.L.).
——— rostratus, *Forbes*† -	Spatangus, Geol. Norf., Tab. 5, f. 7; Forbes, Mem. Geol. Surv., Dec. 4, t. 10; Wright, t. 70, f. 3*a*.	Hartford Bridge (S.W.).
Cidaris sceptrifera, *Mant.* -	C. cretosa, Geol. Suss., t. 17; Dixon, Foss. Suss., t. 25, f. 5, 6; Wright, Cret. Ech., Pal. Soc., t. 5, f. 16, 17; t. 6; t. 7, f. 1, 2; t. 7*a*, f. 1, 3.	Norwich (S.W.).

* Agassiz, L. Description des Echinodermes fossiles de la Suisse, 1839.
† The genus *Infulaster* is now used by Dr. Wright for these species.

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Cyphosoma corollare, *Klein* -	Echinus saxatilis, Geol. Suss., t. 17, f. 2; Wright, *op. cit.*, t. 26, f. 7–10.	Hartford Bridge, St. Giles' Gate (S.W.).
——— Königi, *Mant.* -	Echinus, Dixon, Foss. Suss., t. 25, f. 17, 26, 27; Wright, t. 23, f. 1, 2; t. 24, f. 1–7; t. 25, f. 3; t. 26, f. 1.	Sprowston (S.W.).*
——— magnificum, *Ag.* -	C. Middletoni, S. P. Woodw. MS., Mem. Geol. Surv., Dec. 5, p. 4, Appendix; Wright, t. 25, f. 1, 2 *a–e.*	Near Norwich (J. Middleton), Thorpe (J.K.).
Discoidea cylindrica, *Lam.* -	Scutella depressa, Geol. Norf., t. 5, f. 4, 5; Forbes, Mem. Geol. Surv., Dec. 1, t. 8; Wright, t. 46, f. 1, 2; t. 47, f. 1–3.	Norwich (S.W.).
Echinoconus abbreviatus,† *Desor.*	Galerites vulgaris, Geol. Norf., t. 5, f. 2, 3; Forbes, Dec. 3, t. 8; Wright, t. 52, f. 2 *a–i*; t. 53, f. 1.	Norwich, Hartford Bridge, Trowse (S.W.), Bishop's Bridge, St. James' Pit, Earlham, Thorpe (M.P.G.).
Epiaster gibbus, *Lam.* - -	Spatangus coranguinum in Geol. Norf., t. 5, f. 8; Micraster, Dixon, Foss. Suss., t. 24, f. 5, 6; Wright, t. 63, f. 1 *a–k.*	Hartford Bridge (S.W., T.G.B.), Thorpe (M.P.G.).
Goniaster lunatus, *S. Woodw.* -	Asterias, Geol. Norf., t. 5, f. 1; Forbes, Dec. 2, p. 474.	Norwich (G.S.L.).
——— Mantelli, *Forbes* -	Asterias semilunatus; Mem. Geol. Surv., Dec. 2, p. 472.	Hartford Bridge (S.W.).
——— rectilineus, *McCoy* -	Goniodiscus, Ann. N. H., 1848, p. 408.	Norwich (Morris).
Micraster breviporus, *Ag.* -	Wright, t. 62A, f. 3 *a–b* -	Hartford Bridge.
——— cor-anguinum, *Klein*	Forbes, Dec. 3, f. 10; Wright, t. 62, f. 1 *a–l*, 3, 5.	Hartford Bridge (T.G.B.), Thorpe (M.P.G.).
Salenia geometrica, *Ag.* -	S. Portlockii, Forbes, MS., Dec. 5, App. 5; Agassiz, Mon. Sal., t. 1, f. 25–32; Wright, t. 48, f. 2 *a–g*, 3 *a–b.*	Norwich (N.M.), Thorpe (J.K.).
——— gibba, *Ag.*‡ - -	Mon. Sal., t. 2, f. 9–16; Wright, t. 34, f. 4 *a–e.*	Thorpe (J.K.).
——— magnifica, *Wright* -	Wright, t. 44, f. 1 *a–l* -	Near Norwich.
——— petalifera, *Defr.* -	Echinus areolatus, Asterias; Forbes, Dec. 1, t. 5; Wright, t. 33; t. 42, f. 3.	Norwich, Hartford Bridge (S.W.).

ANNELIDA.

Ditrupa? - - -	- - - - -	Trowse (M.P.G.).
Serpula carinata, *S. Woodw.* -	Geol. Norf., Tab. 5, fig. 13 -	On Ananchytes, &c. (S.W.).
——— contracta, *S. Woodw.* -	Geol. Norf., Tab. 5, fig. 19 -	Norwich (S.W.).
——— fluctuata, *S. Woodw.* -	Geol. Norf., Tab. 5, figs. 15, 16.	On Ananchytes, &c. (S.W.).
——— lituitis, *Defr.* - -	- - - - -	Norwich (Barrois.).
——— lumbricus, *Defr.* -	- - - - -	Norwich (Barrois.).
——— plana, *S. Woodw.* -	Geol. Norf., Tab. 5, fig. 9 -	On Cardiaster, &c., rare (S.W.), on Micraster coranguinum (Nor. Mus. R.E.), on Rhynchonella plicatilis (Nor. Mus. R.E.).
——— obtusa, *Sby.* - -	Min. Con., t. 608, f. 8 -	Norwich (S.W.).

* The occurrence of this species at Norwich is doubted by S. P. Woodward (Geologist, vol. v., p. 42). It is mentioned by Prof. Morris from "Norfolk" (Cat. Foss.), 2nd ed., p. 75.

† *Echinoconus conicus*, Breynius, has not been definitely recorded from the Chalk of Norwich. *See* Forbes on *Galerites albogalerus*, Decade, 3, t. 8; Wright, Pal. Soc., t. 49, f. 2–4, and t. 50, f. 1–6.

‡ Agassiz, L. Monographies d'Echinodermes vivans et fossiles, 1838.

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Serpula plexus, *Sby.* - -	Min. Con., t. 598, f. 1 -	Norwich (S.P.W., G. S.L., T.G.B.), Eaton, St. Giles', common (S.W.), Hartford Bridge (J.K.,M.P.G.).
——— pusilla, *Sby.* - -	Min. Con., t. 635, f. 5 -	Norwich (Morris).
——— spirulæa, *G. B. Sby.* -	Genera, 22 - - -	On Cardiaster, &c., rare (S.W.).
——— vortex, *S. Woodw.* -	Geol. Norf., Tab. 5, fig. 10–12. S. accumulata, S. minuta.	Norwich (S.W.).
Terebella Lewesiensis, *Mant.* -	W. Davies, Geol. Mag. Dec. II., vol. vi., p. 145.	Norwich (T.G.B.).
Vermicularia - - -	- - - - -	Thorpe (J.K.).
Vermilia ampullacea, *Sby.* -	Serpula ampullacea, Min. Con. t. 597, f. 1–5.	Hartford Bridge, St. Giles', common (S.W.), Norwich (Nor. Mus., T.G.B.).
——— macropus, *Sby.* -	Serpula macropus, Min. Con. t. 597, f. 6.	Norwich, on Ananchytes (S.W., T.G.B.).
——— striata, *S. Woodw.* -	Serpula striata, Geol. Norf., Tab. 5, fig. 14.	On Ananchytes, &c. (S.W.).

CRUSTACEA.

Cirripedia.

Loricula pulchella, *G. B. Sby.*	Darwin, Foss. Lep., Pal. Soc. t. 5, f. 1–4.	Norwich (British Museum).
Pollicipes Angelini, *Darw.* -	Foss. Lep., t. 3, f. 7 - -	Norwich.
——— fallax, *Darw.* -	Foss. Lep., t. 3, f. 10 -	Norwich.
——— striatus, *Darw.* -	Foss. Lep., t. 4, f. 5 - -	Norwich.
Pyrgoma cretacea, *H. Woodw.*	Geol. Mag., vol. v., p. 258, pl. xiv., f. 1, 2.	Norwich. (T.G.B.).
Scalpellum* fossula, *Darw.* -	Foss. Lep., t. 1, f. 4; Pollicipes maximus, J. Sby.	Norwich.
——— maximum, *J. Sby.*	Pollicipes maximus, J. Sby.; Foss. Lep., t. 2, f. 1–10.	St. Giles' Gate (S.W.), Hartford Bridge (S.W., *MS.*, M.P.G.).
——— maximum, var. sulcatum, *J. Sby.*	Pollicipes sulcatus, J. Sby.; Foss. Lep., t. 2, f. 3.	Magdalen Chapel, near Norwich, rare (S.W.).
——— maximum, var. cylindraceum, *Darw.*	Foss. Lep., t. 2, f. 2 - -	Norwich.
——— maximum, var. typicum, *Darw.*	Foss. Lep., t. 2, f. 1, 4, 5, 8 -	Norwich.
——— sp. - - -	- - - - -	Trowse, Hartford Bridge (M.P.G.).
Verruca prisca, *Bosquet* -	Darwin, Mon. Bal. & Verr., Pal. Soc. t. 2, f. 10 *a-c.*	Norwich.

Entomostraca.

Cythere umbonata, *Williamson*	Cytheropteron umbonatum, Will.; Jones, Cret. Ent., Pal. Soc. 12, t. 2, f. 3.	Norwich.
Cythereis alata, *Bosquet* -	Jones, Cret. Ent., t. 5, f. 14	Norwich.
——— Lonsdaleiana, *Jones* -	Cret. Ent., t. 5, f. 12 -	Thorpe.
——— macrophthalma, *Bosquet.*	Jones, Cret. Ent., t. 2, f. 8 -	Thorpe.
Cytherella Williamsoniana, *Jones*, var. granulosa.	Cret. Ent., t. 7., f. 26*i* -	Thorpe.

* Specimens of *Scalpellum* have been obtained from Hartford Bridge by Mr. Fitch; and from Thorpe, Postwick, and Whitlingham by Mr. J. King.

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Podophthalmia.

Enoploclytia Sussexiensis, *Mant.*	Geol. Suss., t. 20, f. 3; Palæastacus Dixoni.	Thorpe (J.K.).

Pisces.

Beryx, sp. - - -	- - - - -	Norwich (R.F., J.E.T.).
Cimolichthys Lewesiensis, *Leidy*	Saurodon Leanus, Ag.; Dixon, Foss. Suss., t. 30, f. 28, 29; t. 31*, f. 10.	Norwich (R.F.).
Corax falcatus, *Ag.* - -	Dixon, Foss. Suss., t. 32, f. 10.	Norwich (N.M., R.F.).
—— maximus, *Dixon* -	Dixon, Foss. Suss., t. 30, f. 17.	Norwich (R.F.), Hartford Bridge, Stoke Holy Cross (M.P.G.).
—— pristodontus, *Ag.* -	- - - - - -	Norwich (Barrois).
Dercetis elongatus, *Ag.* -	Dixon, Foss. Suss., t. 34, f. 5	Norwich (Morris).
Edaphodon Sedgwickii ?, *Ag.* -	E. T. Newton, Chimæroid Fishes, Mem. Geol. Survey, p. 11.	Norwich (Brit. Mus., T.G.B.).
Enchodus halocyon, *Ag.* -	Esox Lewesiensis, Dixon, Foss. Suss., t. 30, f. 20, 27; t. 31, f. 11.	Hartford Bridge (S.W.), Norwich (N.M., R.F.?).
Hybodus, sp. - - -	- - - - - -	Bishop's Bridge (M.P.G.).
Hypsodon? - - -	- - - - - -	Norwich (N.M.,M.P.G.).
Ischyodus planus, *Newt.?* -	E. T. Newton, Mem. Geol. Survey, p. 37.	Norwich (T.G.B.),
Lamna acuminata, *Ag.* -	Squalus cornubicus, Dixon, Foss. Suss., p. 30. f. 19, 26, 34, t. 31, f. 18.	Hartford Bridge (S.W.), Norwich (R.F.).
—— subulata, *Ag.* - -	Pictet and Campiche, Fossiles du terrain crétacé de Sainte-Croix, p. 87.	Norwich (R.F.), Bishop's Bridge, St. James' Pit (M.P.G.).
Notidanus microdon, *Ag.* -	Squalus Phillipsii; Dixon, Foss. Suss., t. 30, f. 30.	Norwich (R.F.), Hartford Bridge (S.W.), Bishop's Bridge (M.P.G., N.M.), Thorpe (N.M.), St. James' Pit (M.P.G.).
Odontaspis gracilis, *P.* and *C.*	Pictet, &c., *op. cit.* - -	Bishop's Bridge (M.P.G.).
Osmeroides Lewesiensis, *Mant.*	Salmo Lewesiensis, Dixon, Foss. Suss., t. 33, f. 4.	Hartford Bridge (S.W.).
Otodus appendiculatus, *Ag.* -	Dixon, Foss. Suss., t. 30, f. 25; t. 31, f. 17.	Norwich (G.S.L., C. Barrois).
—— obliquus, *Ag.* - -	Dixon, Foss. Suss., t. 10, f. 32–35.	Norwich (N.M., R.F.).
Oxyrhina heteromorpha, *Reuss.*	- - - - - -	Bishop's Bridge, St. James' Pit (M.P.G.).
—— Mantelli, *Ag.* -	Squalus Zygæna; Dixon, Foss. Suss., t. 30, f. 24.	Norwich (R.F.), Hartford Bridge (S.W.).
Protosphyræna ferox, *Leidy* -	Saurocephalus lanciformis, Harlan. Dixon, Foss. Suss., t. 30, f. 21; t. 31, f. 12; t. 32*, f. 1, 10, 10*; t. 34, f. 14.	Norwich (Morris).
Ptychodus altior, *Ag.* - -	Dixon, Foss. Suss., t. 30, f. 10.	Norwich (R.F. .
—— mammillaris, *Ag.* -	Diodon; Dixon, Foss. Suss., t. 30, f. 6; t. 31, f. 4.	Norwich (R F.), Hartford Bridge (S.W.).
Strophodus? - - -	- - - - - -	Norwich (R.F.).
Tomognathus mordax, *Dixon* -	Dixon, Foss. Suss., t. 35, f. 1	Norwich (Morris).

Reptilia.

Leiodon anceps, *Owen* - -	Mosasaurus. Owen, Cret. Rept., Pal. Soc., t. 9A.	Norwich (N.M., R.F.), St. James' Hill (R.F., M.P.G.), Bishop's Bridge (M.P.G.), Catton (R.F.)
(Mosasauroid bones and teeth)	Dixon, Foss. Suss., Tab. 37, 10–12; t. 38, 8, 9.	Whitlingham (M.P.G.), Horstead (R. Johnson).

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With the exception of Coniferous Wood from a gravel-flint found at Thorpe, near Norwich, no plant-remains have been discovered in the Chalk of the district.* The two species of *Confervites* (*C. fasciculata*, Brong., Woodward, Geol. Norfolk, Tab. 4, fig. 1; and *C. Woodwardi*, Mant., Medals, vol. i., p. 104) are in reality dendritic markings of iron- or manganese-ore.†

In the collection of Mr. T. G. Bayfield (in the British Museum) is a specimen of Terebratula marked *T. paucicostata*, S. P. Woodward, which was obtained from Catton.

Ananchytes Bayfieldi, mentioned in the Catalogue of the Collection in the Museum of Practical Geology (1865), p. 309, was so named by S. P. Woodward, but never described (*see* p. 27). Forbes regarded it as a young specimen of *A. ovatus*. Decade iv., Mem. Geol. Surv., p. 3.

In his paper on the Chalk of Kent (Geol. Mag., vol. vii., p. 466), Mr. G. Dowker observes that "the fossils that occur in the Margate Chalk (its highest "division) are most of them identical with those of the Norwich Chalk," and adds, "it is clear that the Margate Chalk may on this [palæontogical "evidence] be correlated with that of Norwich; and I am of opinion that on "lithological evidence we may assume the Kentish Chalk to be as high, if not "higher, than that of Norfolk." Of 70 species recorded by Mr. Dowker from the Margate Chalk, 35, or only one half, are known from the neighbourhood of Norwich. Species of *Marsupites* are abundant at a lower horizon in Norfolk, (*zone á Marsupites* of Dr. Barrois) and I am disposed to regard the Norwich Chalk (assise á *Belemnitelles*) as constituting a higher zone than that of Margate: a view which Dr. Barrois has already expressed.‡

The following species have been recorded from the Upper Chalk of Trimmingham and other parts of Norfolk, but not definitely from the district described§:—

Nodosaria.
Trochosmilia cornucopiæ, *Duncan*.
Entalophora madreporaria, *D'Orb.*
Eschara echo, *D'Orb.*
Lunulites cretaceus, *Defr.* (L. radiatus).
——— regularis, *D'Orb.*
Inoceramus Cuvieri, *Sby.*
——— involutus, *Sby.*
Baculites magnum, *S. Woodward.*
Cidaris serrata, *Desor.*
Cyphosoma elongatum, *Cott.*
——— granulosum, *Goldf.*
Echinoconus Römeri, *D'Orb.*
Pentacrinus.
Serpula granulata, *Sby.*
——— heptagona? *Von Hag.*
Vermilia pentangulata, *Woodw.*
Cimolichthys (vertebræ), *Leidy.*

Flints.

The flints are nodules of silica, which occur in approximately horizontal (though interrupted) lines from one to six feet apart, and these usually appear to correspond with the lines of bedding. Sometimes, however, they have no connexion with the divisional lines present, and even the flint-layers themselves are often somewhat irregular when looked at in detail, isolated flints occurring above or below the general line.

That the flints are mineral aggregations is proved by their irregular shape, and the fact that they have been formed round various organisms that have served as nuclei and have sometimes moulded their outlines. Of these nuclei may be mentioned reptilian teeth, fish remains, and many kinds of mollusk, sea-urchin, and sponge. In the collection of Mr. T. G. Bayfield (now in the British Museum) is a flint from Catton, in which a black siliceous

* In the collection of Mr. T. E. Amyot, F.R.C.S., of Diss, are specimens of Flint with Algæ.
† *See* Rose, Proc. Geol. Assoc., vol. i., p. 326.
‡ Recherches sur le Terrain Crétacé, p. 136.
§ *See also* Prof. W. J. Sollas, Ann. Mag. Nat. Hist., ser. 5, vol. vi., p. 384.

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pebble is enclosed. That the flints have been formed subsequently to the deposition of the Chalk that immediately surrounds them is indicated by their shape, which could not have been assumed unless the siliceous matter was enveloped and supported, and by the vertical lines of paramoudras which are sometimes connected. That some varieties of flint were formed subsequently to the consolidation of the beds, is suggested by the occasional occurrence of lines of "tabular flint," which sometimes occupy horizontal lines, at others fill vertical joints.*

The silica itself was derived in the first instance from the sea-water, partly by organisms which have to provide themselves with a siliceous framework, as certain Sponges,† Polycistina, and Diatomaceæ. The decay of these, and especially of Sponges, would yield most of the material for the flints in the Chalk. And further, it is considered that the decomposition of certain organisms would produce chemical changes sufficient to eliminate silica from the sea-water, and to assist in its deposition.

From the fact that the majority of flints exhibit spongiform structure, it has been argued that their method of formation was essentially organic.‡ It may, however, be said that the majority of flints enclose organisms, such as Foraminifera, that were once calcareous, and hence it seems clear that the sponges in certain cases simply acted as nuclei, around which the siliceous matter was deposited, while their decay in other cases assisted the process of formation of the flints, causing the soft mud of the Chalk sea to be impregnated with silica.

Flints of very fantastic shape are common at Tharston Furze Hill; also at Trowse.

The most puzzling point is the origin of the layers of flint. Their comparative regularity, looked at in a large way, points to some connexion with the stratification of the rock. In this respect they are analogous to the Septaria of the great clay formations, and to certain forms of Alabaster met with in the New Red Marl. They must have been formed before the Chalk was upraised, and their formation may in some instances have taken place during the process of its drying from saturation, and have been induced or accelerated by the pressure of continual deposits, for it has been stated by Mr. Sorby that mechanical pressure increases the solubility of most substances.

Dr. Wallich, who insists that in their method of origin flints may as truly be considered organic products as the Chalk itself,

* Obliques veins of flint have been noticed in the Chalk near Wells. S. Woodward, Geol. Norfolk, p. 27.

† Dr. Wallich has recently stated his opinion that "the comparatively bulky "siliceous framework and spicule system of the deep-sea vitreous sponges must "constitute the main source of supply of that material [silica] for the flints." Quart. Journ. Geol. Soc., vol. xxxvi., p. 79. Prof. W. J. Sollas considers that in many cases sponge-spicules furnished the silica of flints. Ann. and Mag. Nat., 5th ser., vol. vi., p. 441.

‡ F. Kitton, Trans. Norf. and Norwich Nat. Soc., vol. i., pp. 51, 81; Naturalists' Circular, April 1868, p. 101.

Dr. G. J. Hinde also attributes the silica of flints to the skeletons of siliceous sponges. Fossil Sponge spicules from the Upper Chalk, p. 79.

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has given an explanation of the flint-layers which makes their regularity much more intelligible than it has been hitherto.

The upper layer of Chalk-mud at the bottom of the abyssal ocean is the home of numerous vitreous or siliceous sponges. The mud itself was found by Sir Wyville Thomson to be "entirely "filled with the delicate siliceous root-fibres of the sponges, bind- "ing it together like hairs in mortar. It was actually alive; it "stuck together in lumps, as if there were white of egg mixed "with it; and the glassy mass proved, under the microscope, to "be living sarcode." This sarcode is stated by Dr. Wallich (from whose paper I quote the above passage) to be sponge-protoplasm, a substance almost universally distributed over those areas of the abyssal ocean that are occupied by the calcareous mud; and the protoplasmic layer, owing to its inferior specific gravity, floats, as it were, upon the calcareous mud.

Thus this superficial layer contains a large per-centage of silica, not merely from the sponges themselves, but from the continual subsidence of minute dead siliceous organisms, which become incorporated in its mass. Finally it becomes supersaturated with silica, and the first step towards the consolidation into flint is accomplished.

Flint is itself a colloid, or, in other words, able to form colloidal or gelatinous combinations with albuminous and other materials, and Dr. Wallich remarks that to this "*idiosyncrasy*" of silica were due "the almost perfect incorporation of the organic silica with a "colloid material, the unique *Amœbiform* nodulation of the flints, "and its homogeneousness, whether occurring in nodules, in con- "tinuous sheets parallel to the stratification, or as sluggish over- "flows into fissures in the Chalk."*

This last suggestion is of especial interest when read in conjunction with Ehrenberg's remarks on Paramoudras, quoted a little further on (p. 25).

Some of the vertical layers of flint would seem to have been formed after the partial consolidation and shrinking, if not after the upheaval of the rocks, and when vertical and other joints had been produced.

[Some very suggestive remarks on the formation of flint-layers will be found in the Memoir on the Geology of the neighbourhood of Cambridge, by Messrs. W. H. Penning and A. J. Jukes-Browne, pp. 69–71.]

Paramoudras.

The Norwich Chalk is characterized by the huge flints termed pot-stones, or "paramoudras." These flints vary in length from about 8 inches to 2 feet, and in diameter from 8 inches to at least 3 feet. Still larger forms have been described at Sherringham and Runton by Mr. C. B. Rose. In form the paramoudras are rudely

* Dr. Wallich, Quart. Journ. Geol. Soc., vol. xxxvi., pp. 74, 76, 88, 89. With this paper should also be read the interesting paper by Prof. Sollas, before mentioned.

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cylindrical or tubiform, having a central cavity passing through their longer axis, which occupies a vertical position in the Chalk.

The term Paramoudra has been a source of much perplexity. It was introduced from Ireland by Dr. Buckland, who first described these curious flints found on the coast of Antrim and at Moira, in county Down.* Mr. H. Norton, F.G.S., suggests that the word is an anglicised form of the Gaelic and Erse words for "sea pear," most likely used in the plural, *peura* (or *peira*) *muireach*.

The occurrence of paramoudras in Norfolk was pointed out by R. C. Taylor, and subsequently by Lyell, who observed them both singly in the Chalk, and also arranged in nearly continuous columns at right angles to the ordinary and horizontal layers of small flints. Lyell says:—"I visited, in the year 1825, an extensive range of quarries then open on the river Bure, near Horstead, about six miles from Norwich, which afforded a continuous section, a quarter of a mile in length, of white chalk, exposed to the depth of 26 feet, and covered by a thick bed of gravel. The pot-stones, many of them pear-shaped, were usually about 3 feet in height and 1 foot in their transverse diameter, placed in vertical rows, like pillars at irregular distances from each other, but usually from 20 to 30 feet apart, though sometimes nearer together, as in the above sketch. These rows did not terminate downwards in any instance which I could examine, nor upwards, except at the point where they were cut off abruptly by the bed of gravel. On breaking open the pot-stones, I found an internal cylindrical nucleus of pure chalk, much harder than the ordinary surrounding chalk, and not crumbling to pieces like it, when exposed to the winter's frost. At the distance of half a mile, the vertical piles of pot-stones were much further apart from each other."†

R. C. Taylor observed that not only was the chalk inside the paramoudras impregnated with silex, but also that which separated the flints when one paramoudra occurred above another.‡

A view of the Chalk Pit at Horstead, from a drawing made by the late Mrs. Gunn on September 1st, 1838, has been published in Lyell's Elements of Geology.

On visiting the Horstead pit (the one north of Wroxham Old Hall) 50 years after Lyell, I found only a few scattered paramoudras; in 1878 the pit was closed. Vertical lines of two and sometimes three paramoudras have been exposed in the Chalk at Whitlingham and Trowse; and at St. James's pit, in company with Mr. Whitaker, I saw a line of three if not four paramoudras, which appeared in the layers of flints that were four or five feet apart. One paramoudra was nearly 7 feet long, and extended through two layers of flints.

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* Trans. Geol. Soc., ser. 1, vol. iv., p. 413; *see also* figures by Parkinson, *ibid.*, t. 24; Mantell's Medals, p. 268.

† Elements of Geology, 1865, p. 320.

‡ Trans. Geol. Soc., 2nd ser., vol. i., p. 377.

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So far as my experience goes, many more instances might be cited where the paramoudras occur in an isolated position, or irregularly one to another, than where they occur vertically one above another. Such is the case at Trowse, Whitlingham, and Catton, where they occur in some abundance, as well as at Thorpe and Coltishall. Joshua Trimmer noticed them also at Rackheath Kiln.

Many years ago Mr. R. Fitch pointed out the occurrence of a tube that passed through the long axis of each chalk-nucleus in the centre of the paramoudra. This tube he found to vary in diameter from the thickness of an ordinary-sized quill to that of the finger, and its walls were generally of a greenish colour.* What reference this tube might have to the mode of formation of the flint was left open.

While the paramoudras are sometimes smooth, at others they are covered with numerous flinty processes. Mr. Gunn has remarked that "whenever they come in contact with the horizontal "layers of nodules they are found to throw out side branches, "and to assimilate in form with the nodules; and, again, as their "vertical lines rise above the horizontal layers, they re-assume "their ordinary form."†

So variable indeed are the shapes assumed by huge flints, that I believe a series might be obtained to show transitions from the most symmetrical paramoudra to a large irregular and tabular mass of flint having one or two openings or cavities in it. Mr. T. G. Bayfield had in his collection a paramoudra having a double cavity, and there is a similar "double paramoudra" in the Ipswich Museum.

Paramoudras have by several authorities been regarded as organic bodies. Thus the paramoudra was grouped as a sponge by Samuel Woodward (in his "Synoptical Table of British Organic Remains," p. 5, and in his "Geology of Norfolk," p. 46); Prof. Morris (in his Catalogue of British Fossils, 2nd edit., 1854, p. 29) groups it under the Amorphozoa (Siphonidæ?), with the name *Paramoudra Bucklandi*, Morris; while Mr. R. Tate notes it as *Cœloscyphia Paramoudra*, Buckl., sp. (Quart. Journ. Geol. Soc., vol. xxi., p. 32) and Mr. Kitton is inclined to think it belongs to some species of *Halichondr* (Naturalist's Circular, April 1868, p. 102).

Lyell remarked that "these pear-shaped masses of flint often "resemble in shape and size the large sponges called Neptune's "cups (*Spongia patera*, Hardw.), which grow in the seas of "Sumatra; and if we could suppose a series of such gigantic "sponges to be separated from each other, like trees in a forest, "and the individuals of each successive generation to grow on the "exact spot where the parent sponge died and was enveloped in "calcareous mud, so that they should become piled one above the "other in a vertical column, their growth keeping pace with the "accumulation of the enveloping calcareous mud, a counterpart "of the phenomena of the Horstead pot-stones might be ob-

* Mag. Nat. Hist., 1840, new ser., vol. iv., p. 303, with note by E. Charlesworth.

† Geology of Norfolk, 1864, p. 9. An etching of six specimens of paramoudras accompanied Mrs. Gunn's etching of the Horstead Chalk Pit, from which a woodcut in Lyell's Elements was engraved.

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"tained."* This explanation, if accepted for some of the more definitely formed paramoudras, ought not to lead us to class these bodies as organic remains, inasmuch as the flint is in no case more than a mineral accretion around an organic body. Ehrenberg did not even consider that the forms of the paramoudra were derived from an organic nucleus. He remarked as follows:—

"The sinking of this silica, deriving its origin from organic fragments, by its own gravity, in a funnel shape, through a more solid but naturally still soft layer of chalk, may probably be explained from local circumstances (perhaps from air-cavities), which caused the yielding of the yet soft subjacent chalk, where large horizontal flat masses of silica had collected, and could in its pulpy state still sink in the form of a funnel, when the superior layer of chalk pressing down on it formed the core." †

Such an explanation might account for the lengthened paramoudras seen in the St. James's pit. (*See* remarks, p. 22, 23.)

There is no deposit of clay-with-flints, like that so conspicuous in Hertfordshire and Buckinghamshire, anywhere in the district examined.

The thick beds of flint-gravel, especially those on Mousehold, Poringland, and Strumpshaw Hills, testify to the great destruction of the Chalk; and they are of considerable interest from the many organic remains that have been found in the flints. These are enumerated in the accompanying list, and a study of it will show that a number of the species have not been met with in the Chalk of the neighbourhood.

Of the Sponges not so met with, all the species have been found elsewhere in the Upper Chalk of England. The two Brachiopods, not found in the Norwich Chalk, are Lower Chalk species; and this is also the case with *Inoceramus mytiloides*, *I. undulatus*, and *I. Websterii*, with *Lima aspera*, and *Plicatula inflata*. *Inoceramus Cuvieri* is known from the Upper Chalk of other parts of England. Of the Echinoderms, two of the species, *Catopygus* and *Echinoconus subrotundus* are Lower Chalk forms, the others are found in the Upper Chalk of other parts of England.

A comparison of this list with that of the fossils of the Norwich Chalk will show that there is no foundation for the notion that the sponges indicate a higher zone of Chalk than is developed at Norwich; nor do I think, as has been supposed, that they are more abundant in the gravel-flints than in those obtained directly from the Chalk, an idea which has no doubt arisen from the fact that a much larger number of the former are accessible.

Dr. J. E. Taylor informs me that flint casts of Cliona-borings are confined to specimens from the gravel. The borings were most frequent in shells of *Belemnites* and *Inoceramus*, and the flint casts have been formed by the original dissolution of the shells from the Chalk.*

The list of fossils from the flint-gravels points to a destruction not only of the Upper Chalk, but also of the lower divisions, which appear at the surface in West Norfolk.

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* Elements of Geology, 1865, p. 321.

† Mag. Nat. Hist., 1839, p. 162.

‡ *See* S. P. Woodward, Geol. Mag., vol. ii., p. 576.

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The following List of the species obtained from the flints of the gravel around Norwich has few precise references as to locality, nor is this a matter of much moment. It includes all the species enumerated by S. Woodward (Geol. Norf. p. 36); these are marked "S.W.," and many of the specimens are now in the Norwich Museum. Other specimens, marked "T.G.B.," were collected by Mr. Bayfield, and are now in the British Museum, while those marked "J.K." belonged to the collection of Mr. John King, and were examined and named by Mr. Etheridge. Those marked * have not been recorded from the Chalk of the district, or from flints obtained directly from the Chalk.

List of Fossils found in the Flint-Gravel of the Neighbourhood of Norwich.

Plantæ.

*Coniferous Wood. Thorpe (J.K.).

Spongida.

*Brachiolites (Spongia) labyrinthicus, *Mant.* Norwich (S.W.), Thorpe (J.K.)
*Cephalites (Ventriculites) Benettiæ, *Mant.* (J.K.)
*——— ——— compressus, *T. Smith.* (J.K.)
*Choanites Königi, *Mant.* (S.W., J.K.)
Cliona. (J.K.)
——— cretacea, *Portl.* (Clionites Conybearei, *Morris*, Mag. Nat. Hist., ser. 2., vol. viii.,'Pl. iv., f. 9.)
Cœloptychium agaricoides, *Goldf.* (Nor. Mus.)
Coscinopora globularis, *D'Orb.* (S.W.)
*——— (Spongia) porosa, *Phill.* (S.W.)
*Laterotubigera Cenomana, *D'Orb.* (J.K.)
Scyphia? cribrosa, *Roem.* (S.W.)
Spongia ramosa, *Mant.* (S.W., J.K.)
Ventriculites decurrens, *T. Smith.* (J.K.)
*——— impressus, *T. Smith.* (J.K.)
——— infundibuliformis, *Woodw.* (J.K.)
——— quincuncialis, *T. Smith*, (V. alcyonoides). (S.W., J.K.)
——— radiatus, *Mant.* (S.W., J.K.)
*——— (Spongia) Townsendi, *Mant.* (S.W.)
*Xanthidium, *Ehren.*

Actinozoa.

Parasmilia centralis, *Mant.* (S.W.)

Polyzoa.

*Flustra foliacea?, *Woodw.* (Geol. Norf., Tab. 1, f. 4.) (S.W.)
——— quadrata?, *Woodw.* (Geol. Norf,, Tab. 1, f. 3.) (S.W.)

Mollusca.

Brachiopoda.†

Crania Ignabergensis, *Retz.* (C. striata). (S.W., Nor. Mus.)
Rhynchonella limbata, *Schl.* (Terebratula subplicata). (S.W.)
——— Mantelliana, *Sby.* (T. obliqua). (S.W.)
*——— Martini, *Mant.* (T. pisum). (S.W.)
——— plicatilis, *Sby.* (S.W.)
——— ——— var. octoplicata, *Sby.* (S.W.)
——— ——— var. Woodwardi, *Dav.* (T. Gallina). (S.W.)
*Terebratella (Terebratula) pectita, *Sby.* (S.W.)
Terebratula carnea, *Sby.* (T. elongata). (S.W., Nor. Mus., J.K.)
——— semiglobosa, *Sby.* (S.W.)

† Casts of these are called "Hysterolites." S. Woodward, Geol. Norf., p. 38.

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Lamellibranchiata.

Dianchora lata, *Sby.* (S.W.)
*Inoceramus Cuvieri, *Sby.* ? Mousehold (J.K.)
———— Lamarckii, *Park.* Mousehold (J.K.)
———— latus, *Mant.* (S.W.)
*———— mytiloides, *Mant.* (S.W.)
———— striatus, *Mant.* (S.W.)
*———— undulatus, *Mant.* (S.W.)
*———— Websterii, *Mant.* (S.W.)
———— sp. Strumpshaw (M.P.G.)
*Lima aspera, *Mant.* (S.W.)
—— Brightoniensis, *Mant.* (S.W.)
—— Hoperi, *Sby.* (S.W.)
—— spinosa, *Sby.* (S.W.)
Modiola quadrata, *Sby.* (M. elegans?). (S.W.)
Pecten concentricus, *S. Woodw.* (S.W., Nor. Mus., J.K.)
——— nitidus, *Mant.* (S.W., Nor. Mus.)
——— orbicularis, *Sby.* (Nor. Mus.)
——— sexcostatus, *S. Woodw.* (S.W.)
Pinna sulcata, *Woodw.* Bungay Common (S.W., Nor. Mus.).
*Plicatula inflata, *Sby.* (S.W.)

Gasteropoda.

Pleurotomaria? (Cirrus, Trochus). (S.W.)

Cephalopoda.

Aptychus (J.K.)
Baculites Faujasii, *Sby.* (S.W.)
Belemnitella mucronata, *Schlt.* (with phragmacone). (Nor. Mus., R. Fitch, J.K.)

ECHINOIDEA.

Ananchytes Bayfieldi, *S. P. Woodw.* (MS.) (S.P.W., Nor. Mus.) (*see* p. 20).
———— ovatus, *Leske.* (Spatangus ovalis). (S.W., Nor. Mus., J.K.)
———— planus, *Mant.* (S.W.), Norwich (T.G.B.).
Bourgeticrinus. (T.G.B.)
Cardiaster excentricus, *Rose.* (S.W.)
———— granulosus, *Goldf.* (S.W., Nor. Mus.)
———— pilula, *Lam.* Norwich (T.G.B.)
———— rostratus, *Forbes.* (S.W.)
*Catopygus, sp. (J.K.)
*Cidaris clavigera, *König.* (J.K.)
——— sceptrifera, *Mant.* (C. cretosa). (S.W., J.K.)
Cyphosoma corollare, *Klein.* (Echinus saxatilis). (S.W.)
————, sp. (Nor. Mus., J.K.)
Echinoconus (Galerites) abbreviatus, *Lam.* (S.W.)
*———— ———— conicus, *Breynius.*† (S.W., Nor. Mus., J.K.)
*———— ———— subrotundus, *Mant.* (S.W.)
Epiaster.
Goniaster Mantelli, *Forbes* (Asterias semilunatus). (S.W., T.G.B.)
*———— mosaicus, *Forbes.* (J.K.)
*———— Parkinsoni, *Forbes* (Asterias regularis). (S.W.)
*Marsupites Milleri, *Mant.* Mousehold (J.K.)
Micraster cor-anguinum, *Klein.* (Nor. Mus., J.K.)
*Ophiura serrata, *Römer.* (O. Fitchii, *Forbes*, MS.) Mousehold (R. Fitch).
Salenia geometrica, *Ag.* Norwich (Dr. T. Wright).
—— petalifera, *Defr.* (Echinus areolatus). (S.W.)

† Casts of this species are called "Helmet Stones."

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ANNELIDA.

Vermicularia? (Nor. Mus.)

CRUSTACEA.

Enoploclytia. (J.K.)
Pollicipes? (S.W.)

PISCES.

Osmeroides Lewesiensis, *Mant.* (Salmo.) (S.W.)
Otodus, sp. (J.K.)
——— appendiculatus, *Ag.* (Squalus mustelus). (S.W.)

Besides the fossils here enumerated the following doubtful species have been recorded. S. Woodward records and figures *Erycina complanata* and *Gryphæa minuta*? * The former appears to be a *Lima*, the latter an *Inoceramus*. He includes also *Galerites* (*Echinoconus*) *pentangulus* without figure or reference, and *Pecten muricatus*, which is probably *P. concentricus*. In the possession of Dr. Henry Woodward is a MS. drawing by Dr. S. P. Woodward of a fossil from Mousehold, named by the latter *Pygaster costellatus*? Ag.

S. Woodward also mentions the occurrence of Ætites, "spherical pebbles "having a nucleus originating in a sponge; these are sometimes loose, the "pebbles are then called Eagle-stones." † The term Ætites was given by Pliny.

ECONOMIC PRODUCTS.

The Chalk is extensively burnt for lime, but formerly in many more places than now. The flints are used for building-purposes and for road-mending. The Chalk pits, often called Marl pits, are from about 10 to 40 feet in depth. One of the largest is the pit under St. James' Hill, Mousehold; another is situated above St. Matthew's Church, Thorpe Hamlet, and is a continuation of the Bishop's Bridge pit. The Chalk is also worked by means of tunnels or galleries driven into the hill-slopes, a plan adopted to avoid the removal of the "uncallow" ‡ or superincumbent strata. At Stone Hills, on the Dereham Road, near Norwich, the Chalk is worked by means of galleries, which extend a considerable distance into the hill, branching in various directions. These are not less than 6 feet in height and 6 feet in width, and are sometimes much more lofty. Here the men work with the light of tallow candles. A fall of earth into the workings which took place a year or two ago, caused the air to rush out of the entrance with such force as to do much damage to several wooden buildings adjoining. This mode of working the Chalk was prevalent in former years, and old galleries are frequently disclosed in the modern workings.

Blomefield mentions that "Under St. *Michael's* Mount and "part of Mushold, are surprizing Caverns in the Earth, made by "digging the Chalk Stone for Lime, and the black Flints for

* Geol. Norfolk, tab. 1, figs. 8 and 11.

† *Ibid.*, p. 36; Synopt. Table, p. 41; *see also* Parkinson, Org. Rem., vol. ii., table 12, fig. 5.

‡ *Uncallow.*—This term is locally applied to the material in a pit which is not wanted; thus where Chalk is worked the Crag is frequently called the "uncallow"; where brickearth is dug the overlying sand or gravel may be similarly designated.

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" Building, with which these Pitts abound."* Old galleries have been exposed in St. James' Pit.

An old working known as the "Whitlingham Cave" was closed about seven or eight years ago.

In December 1823, when digging a well at Heigham Hill (St. Giles' Gate), near Norwich, the workmen suddenly came upon some extensive workings in the Chalk. These were described by Mr. G. W. Featherstonhaugh as consisting of various galleries about 8 feet in height, and from 2 to 5 feet in breadth, and occupying a total length of 4,600 feet. He explained that the object of these workings was to extract the flints, which were used in great quantity in the construction of the ancient buildings and walls of Norwich. Upon re-opening the original entrance, which had been blocked up by ruins, the date 1571, with the name of one of the workmen, was found written on the side of the cavern, a year which was stated by Mr. Featherstonhaugh to correspond with a period when the walls of the city are known to have been repaired with flints, and various buildings formed of them.† To this account of the workings Samuel Woodward adds the following: ‡ "They are situate just without the walls " on the slope of the high ground which faces the north, in which " slope were the original entrances now filled with earth. It " appears from our local historian [Blomefield] that an order was " issued by the Mayor in the time of Queen Elizabeth, that " before the arrival of the Queen (then on her progress through " Norfolk) the hills or heaps of dirt accumulated on the spot " should be levelled; hence appears to have originated the " closing of these curious caverns, the rubbish having been " thrown down the slope over the entrance. A date, 'John " 'Bond, 1571,' scratched in the Chalk, is somewhat confirma- " tory of this, it being only seven years prior to the arrival of " the Queen in 1578."

In the parish of Horstead, where the Chalk rises from a few feet to about 25 feet above the level of the River Bure, pits which have been opened by the river-side have been extended into the hills, in one locality for more than half a mile. As the Chalk was worked away so a channel was made to allow the water to flow up to the portion of the pit worked, for the convenience of the wherries. These old workings are all deserted now, and as the slopes have been planted with fir and larch, they present a very picturesque appearance, and the one mentioned by Lyell (*see* p. 23) is generally known as "Little Switzerland"; a high arch spans the canal at one point.

Another picturesque canal is situated near Wroxham Old Hall.

Among the old pits now obscured was the City Limekiln, situated a little north-west of St. Peter's at Southgate; another

* Fol. Edit. (Norwich), p. 798.
† Proc. Geol. Soc., vol. i., p. 85.
‡ Letter to Dr. Goldie, of York, dated 21 January 1830.

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is immediately opposite the residence of J. J. Colman, Esq., M.P., at Carrow; while a third was situated between the churches of St. Michael at Thorn, and St. Julian. The old pit to the S.E. of Bishop's Bridge was called the Lollard's Pit, because there the followers of John Wyclif were "customably burnt."

It is stated that indurated Chalk or "clunch" obtained from the pits at Mousehold was formerly applied to the construction of the tracery of windows, &c.

In Thorpe village some of the old Chalk pits are now converted into private gardens.

Flints have been largely used for building purposes, in most cases in the form of boulders derived from the gravels (*see* p. 129).

Inlaid flint-work in church towers and porches is not uncommon. In the Museum at Jermyn Street, is a specimen of mosaic work designed by Frewer, of Catton.

The Old Bridewell by St. Andrew's Church, Norwich, erected about 1400, is a fine specimen of flint work, according to Blomefield, "being esteemed the most curious wall of black flints "in all *England* for its neat work and look, the stones being "broken so smooth and joined so well."

The faces of these flints are covered with pittings, evidently due, so my colleague Mr. S. B. J. Skertchly observed, to the fact that in the original setting of the flints the workmen gave each one numerous taps with probably a wooden mallet, in order to fix it in position, and the blows induced incipient conchoidal fractures which were afterwards perfected by the action of the weather.

At Hartford Bridge and at Chalk Farm, St. Augustine's, Norwich, the Chalk is manufactured into whiting and linseed-oil putty. From Whitlingham the Chalk is sent to aid in the manufacture of Portland cement, at Burgh Castle, near Yarmouth.

At Attoe's Pit, Catton, gun-flints were until recently manufactured for export to South Africa by a man named Frewer, and by his son, but only at irregular intervals, and when ordered. The best flints were obtained in the "Sink bed"; that is, in the basement beds of the pit above or near the water line, where the flints were wet and unweathered. The top beds were not used. The flints both here and at Whitlingham, which are grey and black, are now worked and dressed for building purposes, being shaped into blocks with square or oblong faces. Gun-flints are occasionally manufactured at Whitlingham, and Mr. Skertchly mentions that Norwich flint has recently been brought to Brandon, owing to the falling off of the local supply.*

The Chalk itself hardly enters into the agriculture of the district, being generally covered with Crag and Drift, or obscured by rain-wash on the slopes. West of Keswick Church, and between the church and Chapel Hill, the Chalk appears quite bare at the surface.

* *See* Memoir on the Manufacture of Gun Flints, 1879, pp. 10, 14.

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CHAPTER III.—TERTIARY.

Eocene.

Although the Lower London Tertiaries (Woolwich and Reading Beds and London Clay) have not been observed at the surface, there is very little doubt that they are to be found beneath the Pliocene strata in the eastern part of the area.

Their occurrence at Yarmouth was made known in 1860 by Prof. Prestwich, and there 46 feet of Woolwich and Reading Beds and 310 feet of London Clay were described beneath 170 feet of newer deposits.* These Eocene beds therefore are probably present above the Chalk to the east of Surlingham and Wroxham, but in the absence of any borings their precise boundary can only be matter for conjecture. (See Plate I., fig. 2.)

Pliocene—Upper Crag†—Norwich Crag Series.

General Remarks.

Under this heading are included all the beds in the district which are exposed between the Glacial Drift and Chalk. The Upper Crag thus comprises a variable group of sands, pebbly gravels, and laminated clays, with occasional seams or patches of shells. Near Norwich and in the Bure Valley it has a general thickness of about 30 feet, but at Beccles it attains as much as 95 feet, excluding the upper pebbly division.

The ordinary succession of the beds is as follows :—

4. Buff false-bedded sand and red gravel, formed chiefly of flint pebbles, with also pebbles of quartz, and ironstone nodules. Veins and seams of laminated clay occur, and the gravel is occasionally cemented into a conglomerate or "Iron-pan."‡ [This division has been called the Pebbly Sands and Pebble beds, the Bure Valley Beds, also the Westleton Beds.]
3. Laminated clay, with seams of sand and gravel; or clay and sand in thin layers rapidly alternating. [This division has been called the Chillesford Clay.]
2. White and brown sand with pebbly gravel and ironstone nodules. [This division, including also No. 1, has been separated into an Upper or Chillesford Crag, and a Lower or Fluvio-marine Crag.]
1. Bed of unworn and rolled flints, called the "Mammaliferous Stone-bed."

Chalk with flints.

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* Quart. Journ. Geol. Soc., vol. xvi., p. 449.

† The term Upper Crag is used by the Geological Survey to include equivalents of Red and Norwich Crags, in distinction from the Lower Crag which includes the Coralline Crag.

‡ *Iron-pan.*—This term is locally applied to any bed of gravel or sand which has been cemented into a conglomerate or hard sandstone by iron-oxide. The term *Chingle* is sometimes applied to the pebbly gravel, being "gravel free from dirt" or shingle.

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Shells are most abundant in beds 1 and 2. They include *Astarte borealis, A. compressa, Cardium edule, Corbula striata, Cyprina Islandica, Leda oblongoides, Lucina borealis, Mactra ovalis, Mya arenaria, Mytilus edulis, Nucula Cobboldiæ, Pecten opercularis, Tellina obliqua, T. lata, T. prætenuis, Cerithium tricinctum, Litorina litorea, Purpura lapillus, Scalaria Grœnlandica, Trophon antiquus, Turitella incrassata, T. terebra.* Of these, all are living species, with the exception of *Tellina obliqua, T. prætenuis,* and *Cerithium tricinctum;* while *Nucula Cobboldiæ* and *Leda oblongoides* if not actually living at the present day are very nearly represented. The shells occur very often comminuted, but sometimes entire, and in their natural positions.

The bands of clay (3) have no doubt served in some instances to protect the shells from destruction by percolating waters, for when they occur in the pebbly gravel (4) they are generally in the form of casts. A species considered to be peculiar to the upper gravelly division is the *Tellina Balthica,* hence the "Bure Valley Beds" are sometimes called the "Tellina-Balthica Crag:" no further value, however, attaches to the division than that of a zone. The Weybourn Crag belongs to the same division.

The impersistence of the shell-beds has been the subject of remark by almost every observer. In by far the larger number of sections of the Crag no organic remains have been found. In some pits where their former abundance has been testified to, they are now rare, or the seam has been entirely worked away. While on the other hand, pits at one time yielding no shells have now become fossiliferous. Hence considerable interest is attached to every pit that is being worked.

To its occasionally fossiliferous nature the Crag owes the attention it has received. The shells were so early as 1729 noticed by John Woodward in his celebrated Catalogue, and they were subsequently illustrated by Parkinson, William Smith, and Sowerby.

The earliest descriptions of the strata are contained in the writings of Arderon dating 1746, since which time they were not particularly noticed until, in 1823, R. C. Taylor gave a clear and excellent description of the beds, and first applied in a definite geological sense the term Crag, a word commonly used in Suffolk to designate any shelly sand or gravel.

Later, in 1833, the beds were described and most of the species were figured by Samuel Woodward; and in 1836 Mr. Charlesworth proposed the term Mammaliferous Crag to distinguish the Crag beds of Norfolk from the Red and Coralline Crags which he had previously separated.* The term Norwich Crag was subsequently employed by Lyell in 1839.† Thus the terms Mammaliferous or Norwich Crag came into use, and as a rule they were

* The term "Icenian" was proposed by S. P. Woodward for the Pliocene strata, because their order of succession was first determined, by Mr. Charlesworth, in the eastern counties of England, the country of the Iceni. Manual of Mollusca, p. 410.

† Buckland, Address to Geol. Soc. 1840.

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taken to include the group of beds here considered as Upper Crag. The term Norfolk Crag was employed by John Phillips,* and Upper Crag by Mr. Godwin-Austen.†

Of late years the beds and fossils in the principal sections have been examined and described very minutely, and it has been sought to establish divisions that have been made out in the so-called typical section at Bramerton, and to correlate divisions in other sections with them.

Certain lithological characters and certain species of mollusca have been taken as guides in forming the subdivisions; but unfortunately the numerous observers have not only, as a rule, taken different views but have used different terms; hence there have been imported into the subject of the Pliocene deposits of Norfolk such a number of local names and synonyms that the literature is very confusing to the student.‡

Thus in 1865 Mr. J. E. Taylor pointed out the differences in the two shell beds exposed in the Crag on Bramerton Common. The upper bed contains a larger per-centage of northern mollusca, and the most abundant species in it belong to somewhat deeper water than those found in the lower division.§

Subsequently Mr. S. V. Wood, jun., correlated this upper bed of Crag with the Chillesford shell-bed above the Red Crag, and he paralleled a vein of brown clay which almost immediately overlies it, with the Chillesford Clay. The lower bed of Crag at Bramerton he regarded as the fluvio-marine equivalent of the upper portion of the Red Crag.

More recently Messrs. Wood and Harmer separated the fossiliferous pebbly sands and gravels of Belaugh, Wroxham, Crostwick, and other places in the Bure Valley from the Norwich Crag, regarding the occurrence in them of *Tellina Balthica* (*solidula*) as an indication of their distinct age. And hence these pebbly sands came to be regarded by them as "Lower Glacial Sands," and (in 1866) called the "Bure Valley Beds."‖

Still later Prof. Prestwich divided the beds into Norwich Crag, Chillesford Clay, and Westleton Shingle. He included most of the fossiliferous beds, whether with or without *Tellina Balthica*, as Norwich Crag. His Westleton Beds are, in the district now described, generally equivalent to the Bure Valley Beds.¶

The Crag has been described as a variable group of sands, pebbly gravels, and laminated clays, with occasional seams or patches of shells. And this is not only true of the several sections, if, for instance, we compare those at Thorpe, Postwick, Bramerton, and Whitlingham, one with another, but it is equally true of the sections themselves, for as these are in course of time cut back for economic purposes, the sections vary continually, owing to the extensive false-bedding. None of the beds are persistent.

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* Rep. Brit. Assoc. 1863, Trans. of Sections, p. 85.

† Brit. Assoc. 1868; Geol. Mag., vol. v., p. 475.

‡ The name Norwich Crag is not even used by Messrs. Wood and Harmer in their map of the Crag District.

§ Geol. Mag., vol. viii., p. 314.

‖ See Geol. Mag., vol. v., p. 455; vol. vi., p. 232; vol. vii., p. 20. Quart. Journ. Geol. Soc., vol. xxii., p. 547. See also Proc. Norwich Geol. Soc., vol. i., p. 50. Although *Tellina Balthica* was recorded by Mr. S. V. Wood from the Crag at Bramerton (Mon. Crag. Moll. vol. ii. p. 232) and by Dr. S. P. Woodward from Postwick top-bed (Gunn's Geology of Norfolk), these appear to have originated in mistakes. Harmer, Trans. Norf. and Norw. Nat. Soc., vol. ii., p. 377. I have also seen a specimen of this shell in the Leeds Museum marked "Bramerton."

¶ Quart. Journ. Geol. Soc., vol. xxvii., 1871, p. 452.

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The attempted subdivisions and correlations have been made on lithological and palæontological grounds.

On lithological grounds the Chillesford Clay has been taken as an horizon. It has been described as a beautifully laminated clay, comprising in reality rapid alternations of clay and sand, both very micaceous. At Aldeby, Surlingham, Hartford Bridge, South Walsham, Hoveton (near Wroxham Railway Station), Coltishall, and Ludham, there are good "jambs" of clay,* from 3 or 4 to 15 or 18 feet in thickness. These possess almost identical characters. But at the "typical" localities of Thorpe, Postwick, and Bramerton, there is no conspicuous development of clay, and where veins are present they do not possess that beautiful lamination said to be characteristic of the Chillesford Clay. One who visited the before-mentioned localities in succession would undoubtedly go away convinced that the Chillesford Clay was a well-marked horizon in Norfolk. But if he endeavoured to trace out these clays on the ground, noticing the intermediate sections, and the behaviour of the clays themselves, he would become convinced that while such laminated clays are *characteristic* of the Pliocene beds of Norfolk, they are not confined to one horizon, they were not all deposited at one particular time, and their absence is not necessarily the result of denudation.

The sections at Coltishall and Hartford Bridge demonstrate that these clays are intimately connected by false-bedding with the pebbly gravels that often overlie them, and that they pass occasionally by interbedding in their horizontal extension into sand and gravel. In some sections we find two or more bands of clay, any one of which might on lithological grounds be termed the Chillesford Clay.

In other sections the lenticular or false-bedded character of the clays is exhibited. No where, however, are such features better shown than in the coast-sections between Cromer in Norfolk and Southwold in Suffolk, where the "Pre-glacial laminated series" of Mr. J. Gunn exhibits many beds identical in character with "typical" Chillesford Clay, and in two if not more distinct horizons. Moreover the frequently abrupt termination of such laminated beds, and their constant change in character, do away with the faith which has been upheld, that such finely laminated beds must have belonged to a widespread deposit.

Hence the pebbly gravel that often overlies these clays does not necessarily belong to a distinct group. The symptoms of slight erosion found here and there, where the pebbly gravel rests on the clay, is but a character prevalent in the series at all stages, and might naturally be expected from the deposition of a shingle over a soft clay. In some instances, too, erosion has taken place in comparatively recent times by springs thrown out by the clay. At Coltishall the upper surface of a lower part of the laminated

* The term "jam" or "jamb" is applied to any impersistent, and generally lenticular mass of clay, marl, or brickearth—it is a bed "jammed between other strata."—(*Nall.*) Some of these beds of clay are shown on the Geological Survey Maps. *See* note, p. 6.

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clay has been eroded, and overlaid by a lenticular mass of sand, and the same feature was to be seen at Hartford Bridge.

In some cases, of course, clay may form the upper part of the Crag series, and Glacial sands may rest directly and unconformably upon it.

Thus these clays of the Crag series will be spoken of as laminated clays, the term Chillesford Clay not being in my opinion applicable or necessary, beyond the limits where that particular clay can be continuously traced. It is undoubtedly represented in the Upper Crag, but whether by sand, gravel, or clay, in the several sections that have come under my notice, I could not pretend to say.*

In some places the pit-sections show streaks of clay from top to bottom, and when these have been deserted for a time, the moss *Funaria hygrometrica* thickly coats the exposed edges of the clay seams, marking them out from the sandy and gravelly beds intercalated, and adding much to the pretty appearance of the false-bedding. Hence the term "Laminated Series" applied to the Pliocene beds of East Anglia by Mr. Gunn is a very appropriate one.

Turning now to the divisions based on organic remains, it is a fact that the two beds at Bramerton Common present some differences of local interest. But the two beds are merely separated by a few feet of false-bedded sand, which contains shells sparingly! And while the lower bed contains a larger assemblage of species, only three rare forms found in the upper bed have not been obtained in the lower. The lower bed has been termed by Lyell the Fluvio-marine Crag, because containing a mixture of marine, land, and freshwater shells, with bones of fishes and mammalia, it was clearly accumulated at the bottom of a sea near the mouth of a river.† The influence of freshets is seen in the varieties and monstrosities of the Purples and Periwinkles. But the deposit itself and the majority of the organic remains are so decidedly marine, that the term Fluvio-marine, as remarked to me by Mr. Bristow and also by Mr. Etheridge, is rather apt to mislead. While numbers of freshwater shells from the Crag may be seen in Museums and private collections, they are with one exception (*Hydrobia subumbilicata*) exceedingly rare in the deposit. Borings of *Pholas* and marine Annelides occur in the Chalk at the base of the Stone bed, and among the boulders and sometimes in crevices of the Chalk there occur, at Thorpe near Norwich, many specimens of *Pecten opercularis* and *Tellina crassa*. Mr. T. G. Bayfield has mentioned his finding in the Stone bed a large flint covered with not less than 200 barnacles.‡

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* In a paper published, in 1867, Mr. George Maw expressed his opinion that the Chillesford Clay was "really part and parcel of the Upper Norwich Crag." Geol. Mag., vol. iv., p. 99. Mr. Blake in his notes (pp. 78, 79) positively identifies this clay at Reedham and Moulton. *See also* Proc. Norwich Geol. Soc., vol. i., p. 159.

† Student's Manual, p. 169.

‡ Norfolk News, Aug. 6, 1870.

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The upper bed at Bramerton is correlated with the seam of shells at Brundall, and with the Crag at Aldeby, Horstead, and Burgh near Aylsham. But the Crag of Horstead and that also of Belaugh ("Bure Valley Beds") is regarded by Messrs. Wood and Harmer as fluvio-marine in character.* Hence the application of fluvio-marine to the lower bed at Bramerton is as ambiguous as it is unnecessary, for as Mr. Godwin-Austen has remarked, "the "fluvio-marine portions of the Norwich Crag are simply the indi- "cations of the places where rivers discharged into the sea."†

Moreover from the fact that there is no hard line between the divisions made out at Bramerton, and that they are there connected by occasional shells through the intervening sand, there is nothing to show that the equivalent of this sand may not elsewhere be represented by a mass of shells. It cannot be said positively that the shell beds at Aldeby, Brundall, and Coltishall were formed precisely at the time when the uppermost Crag of Bramerton was laid down.

Then as regards the so-called "Bure Valley Crag" of Belaugh, &c., only two species found in this zone are not positively known to occur in the Crag near Norwich, namely, *Tellina Balthica*, and *Paludina vivipara*; and it is nowhere seen in section, in its fossiliferous form, above the two other "zones" of Crag.

All the comparisons are based on the one so-called typical section at Bramerton, where the uppermost zone shows the comparative abundance of the slightly deeper-water and more boreal forms, suggesting slow submergence attended by gradual alterations in the climatic conditions. Trifling indeed would be the alterations, for in number of boreal *species* the lower crag furnishes a larger list than the upper crag. The lower bed is, however, conspicuous for the *abundance* of litoral shells.

When we come to study the shells in the several beds of Crag, even those acknowledged to be on the same horizon, we find that they vary not only in the abundance of particular forms, but also in the number of different species, indicating perhaps slightly varying depths of water or diversities in the sea-bed, that influenced their distribution.‡

At Brundall Station *Nucula Cobboldiæ* is very abundant. At Brundall Church, a bed distinctly on the same horizon; this shell is rare, and *Cyprina Islandica* is met with in profusion in entire shells. At Blake's pit, Bramerton, *Scrobicularia plana* is abundant, while it is exceedingly rare in the adjoining pit on the Common. And *Calyptræa Chinensis* and *Loripes divaricatus* are abundant in a lane-cutting close by, in Kirby Bedon parish, and not nearly so common in either of the pits at Bramerton.

At Arminghall *Mactra solida* is so abundant that Mr. J. E. Taylor well observed that the deposit might be called the *Mactra*-bed. In one pit at Wroxham, *Astarte borealis* is particularly common, *Tellina Balthica* is very rare. While at Belaugh the reverse is the case.

* *See* Supp. to Crag Mollusca, p. 112.
† Quart. Journ. Geol. Soc., vol. vii., p. 129.
‡ *See* remarks by Professor Prestwich, Quart. Journ. Geol. Soc., vol. xxvii., p. 472.

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Speaking generally of the Crag formation, Mr. S. V. Wood, sen., has stated that several species formerly abundant had entirely eluded his search of late years, and this within a few yards distance of, and on the same vertical horizon as, the place of their former occurrence. On the other hand, some of those previously considered rare had become more plentiful.

Mr. Bayfield has told me that some species considered as good finds in his younger days are now comparatively abundant, and among these the *Nucula Cobboldiæ* found at Brundall.

A study of the subject in conjunction with the Suffolk Crag leads to the suggestion that the area was gradually being depressed, and that the land to the north was being slowly submerged, so that the Chalk cliffs which then formed the coast line were gradually destroyed northwards and westwards,* and the neighbourhood of Norwich came within the influence of the Crag sea before that of the Bure Valley. And this gradual submergence perhaps finally led to the introduction of the *Tellina Balthica* by the opening up of a connexion with some previously distinct area. Granting this to have been the case, we cannot anywhere draw hard lines to mark zones or stages; believing that not only sands, gravels, and clays, but also shell-beds were forming at one and the same time in different areas throughout the history of the Norwich Crag; that in fact there was an uninterrupted succession of life and shell-deposits however locally they may be preserved. In fact the method of formation of the deposits is illustrated in the German Ocean at the present day, the charts of which display the varying nature of the deposits therein accumulated, while the Norfolk coast itself displays every variety of beach-deposit, fine sand, shingle, and boulder gravel.

Prof. Prestwich† speaks of the Norwich Crag as formed in sandy bays, and mentions in support of the inflowing of streams from the north and west, the occurrence in the Crag at Norwich of Lias Ammonites, Mountain-Limestone corals, besides many fossils from the Chalk.

Rhynchonella plicatilis, *Belemnitella lanceolata*, and *Ammonites communis*, have been recorded by S. Woodward from the Norwich Crag;‡ Lyell mentions *Trophon* (*Murex*) *alveolatus*, and *Hinnites*.§ Jet, Lignite, and Beekite have also been found in it.

Evidence of the transport of blocks by ice-floes occurs in the Coralline and Red Crags, and Mr. S. V. Wood has suggested that the influx of ice might account for the production of some of the deformities in the mollusca of the Crag.‖

The rapid alternation of sand and clay, so characteristic of the laminated beds, may perhaps be explained as Mr. H. Norton sug-

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* *See* Fisher, Geol. Mag., vol. v., pp. 544, 545.
† Quart. Journ. Geol. Soc., vol. xxvii., p. 476.
‡ Geol. Norfolk, p. 45.
§ Mag. Nat. Hist., 1839, new series, vol. iii., p. 321.
‖ Crag Mollusca, vol. ii., p. 280.

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gested to me, by regarding the clay as the mud brought down by a river, and the sand as washed over it by the incoming tide; although such a process seems rather too rapid a method of proceeding. Some of the beds also present a wavy appearance analogous to what Prof. Phillips has described in Kilnsea Cliff, Yorkshire, where beds of silt or warp are "disposed in thin "parallel laminæ remarkably undulated; as if sediments derived "from inundations had been subject to very uniform *rippling*."*

The fact of some erosion having taken place during the accumulation of the beds is indicated by the clay-pebbles which are found at all horizons in the Crag series. These are due to the breaking up of some previously deposited clay-seam, and I believe they formed the nucleus for those clay-ironstone concretions which are so characteristic of the formation.†

The Crag is exposed on the borders of the valleys of the Bure, Yare, and Waveney, and their tributaries; in the Bure valley it covers the larger extent of ground.

Wherever it has been observed in the area, it rests upon the Chalk, and there is no difficulty and no dispute about the lower boundary-line of the formation. But inasmuch as it is sometimes covered evenly and with apparent conformity by deposits belonging to the Glacial period, it is not always easy and sometimes impossible to draw a hard and fast line between them. Such is the case in the escarpment running from Trowse to Stoke Holy Cross, and we can only approximately mark off the boundary between the Crag and Glacial deposits in accordance with the average thickness maintained by the former deposit, where its limits can be definitely determined.

The chief *Fossiliferous localities* are Thorpe, Postwick, Bramerton, Whitlingham, and Brundall, in the Yare Valley; and Wroxham, Belaugh, and Coltishall, in the Bure Valley. To these may be added several other names of places now or formerly fossiliferous, Attlebridge and Catton, in the Wensum Valley; Kirby Bedon, Trowse, Arminghall, Lakenham, Shottesham, Forncett, Newton Flotman, Stoke Holy Cross, and Saxlingham, in the valley of the Yare and its tributaries; Salhouse, Rackheath, Crostwick, Spixworth, Horstead, Stratton Strawless, and Marsham in the Bure Valley; and Ditchingham and Beccles in the Waveney Valley.

Although the term Mammaliferous Crag was applied by Mr. Charlesworth, from the occurrence in it of the remains of mastodon, elephant, deer, &c., yet these remains are so rare in the Crag that it falls to the lot of few collectors to obtain specimens themselves; and most of those which enrich our public and private collections were obtained from the workmen engaged in digging the Crag.

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* Rivers, &c., of Yorkshire, p. 122.

† Under the name of "Ætites Geodes," their occurrence was noted at "Moosal-Hill" [Mousehold], near Norwich. J. Woodward, Catalogue (1728), Tome II., p. 103. *See also* H. B. W., Proc. Geol. Assoc., vol. v., p. 514.

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Probably not more than twenty teeth of the Mastodon* have been obtained, but this form possesses peculiar interest from the fact that it has not at present been discovered in the Forest Bed Series with which the Crag is so intimately associated.

It is the general opinion, and one confirmed by the testimony of the workmen, that the mammalian remains are most abundant in the lower portions of the Crag. Its basement bed consists of a layer of more or less rolled flints with a few pebbles of quartz and quartzite, embedded in a clayey or sandy matrix, and it has been termed by Mr. Gunn the "Mammaliferous Stone Bed," from the fact that so many bones have been obtained from it.

The bones found at Thorpe, and I have obtained numerous specimens, are, however, most abundant immediately *above* the stone bed, few occurring in it. During the past three or four years the Crag has been extensively removed and the stone bed well exposed. On one occasion a portion of the tusk of an Elephant was found *on* the Stone bed. Still the specimens are sufficiently near the "Stone-bed" to support the statement that bones are most abundant in the lower portions of the Crag, though I do not believe they have any special connection with the "Stone-bed," or that this bed ought to be separated from the Crag.

Instances are on record of Mammalian remains having been obtained at some distance above the base of the Crag, as at Surlingham, where the tooth of a Mastodon was obtained by the workmen in a bed of sandy gravel just above the mass of laminated clay so largely worked (*see* p. 83). The exact spot from which this specimen was obtained was pointed out to me by Mr. Gunn, in 1873, who explained that the specimen showed signs of having been derived from some lower bed, in portions of a hard gravelly matrix adhering to the tooth, and which was distinct from the beds in which it was deposited.†

At Coltishall and Aldeby mammalian remains have been found in the pebbly gravel overlying the clay-beds at those localities.

The evidence shows that the bones may belong to the period as much as the shells which occur abundantly in the stone-bed and in crevices of the Chalk. Although it may in part comprise relics of some old land-surface destroyed during the formation of the Crag, it is hardly possible that any portion of the Chalk itself is an old land surface.‡ At Postwick the surface of the Chalk, as is well known, is bored by marine shells and annelides; and at Bramerton the presence of Pholas-burrows has also been pointed out.

The Stone bed is therefore part of the Norwich Crag, and its formation, as has been pointed out, was very likely somewhat

* Noticed by Parkinson (1811), Org. Rem., p. 449. A grinder of the Mastodon found at Whitlingham was figured, in 1816, by William Smith in his "Strata Identified by Organized Fossils."

† Meeting of Norwich Geol. Soc., Norfolk News, February 8, 1873.-

‡ *See* Fisher, Geol. Mag., vol. v., p. 546.

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analogous to that of the coarse flint beaches of Trimmingham and Runton, where the flints are worked directly out of the Chalk.* Hence it may be of slightly different ages as the Crag sea encroached further and further north.

The Mastodon it is true lived in earlier times, and its remains might have become embedded in some freshwater or lacustrine deposit, whose destruction, as suggested by Mr. Harmer, yielded the remains found in our Norwich Crag; and yet it is quite as likely that it lived on to Pliocene times, and that remains of the animal might be found on the beach and in some cases rapidly covered up and preserved.†

Captain Alexander discovered an elephant's tusk, with many serpulæ attached to it in the Norwich Crag;‡ while the probable occurrence of a nearly entire skeleton of the Mastodon at Horstead has been made known (*see* p. 57).

From the state of preservation of the specimens in Mr. Fitch's collection, my colleague, Mr. E. T. Newton, was of opinion that they could not have been derived but belonged to animals that had lived in the Crag period.

The following list of fossils from the Norwich Crag includes all the published records of species from the several localities mentioned, and those collected by myself and Mr. C. Reid during the progress of the Geological Survey. The letters M. P. G. refer to specimens in the Museum of Practical Geology, which have been identified by Mr. Etheridge.

Of the published works, the Monograph of the Crag Mollusca by Mr. S. V. Wood has been my guide not only for some localities, but for the proper names of the species of shells.

The list of shells of the Newer Pliocene or Norwich Crag published by my father, the late Dr. S. P. Woodward, includes the species in the collections of R. Wigham (in the British Museum), John Middleton (in Norwich), Capt. Henry Alexander (dispersed), W. K. Bridgman (in Norwich), R. Fitch (in Norwich), and T. G. Bayfield (in Norwich).

Of special lists, that of Mr. James Reeve from the pits at Bramerton (Proc. Norwich Geol. Soc., vol. i., pp. 69, 110), that of Messrs. W. M. Crowfoot and E. T. Dowson from Aldeby (ibid. p. 24), and that of Mr. Crowfoot from Beccles (ibid. p. 76) have been incorporated.

The lists in the paper of Prof. Prestwich, Quart. Journ. Geol. Soc. vol. xxvii., p. 452, and in the various papers of Messrs. Wood and Harmer, J. E. Taylor, and the Norwich Geological Society have been made use of. The list from Belaugh by Messrs. Wood and Harmer (Geol. Mag., vi., p. 232), was kindly revised by them.

Some species in the collections of the late John King, of Mr. R. Fitch, and the Norwich Museum, are inserted on the authority of Mr. R. Etheridge and Mr. E. T. Newton. Some localities are given on the authority of S. Woodward and of Mr. John Gunn. In all cases the initials noted in the list will be understood from the foregoing statement.

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* *See* S. Woodward, Geol. Norfolk, p. 20; F. W. Harmer, Quart. Journ. Geol. Soc., vol. xxxiii., p. 139.

† Dr. Falconer, regarded the Mammalian fauna of the "Fluvio-marine Crag as of Pliocene age," Quart. Journ. Geol. Soc., vol. xiii., p. 53.

‡ Lyell, Proc. Geol. Soc., vol. iii., p. 128.

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References are given wherever possible to figures of the species obtained from the Norwich Crag; in some instances, however, the *specimens* figured have not been obtained in the Crag. The full titles of most of the works referred to will be found in the Appendix. Figures of all the shells (excepting *Litorina petræa*, for which *see* the "British Conchology," by J. Gwyn Jeffreys) will be found in Mr. Wood's Crag Mollusca, and the two Supplements to it, published by the Palæontographical Society. Where the names of species differ from those given in S. Woodward's Geology of Norfolk, and in some other instances the synonyms are added.

The following abbreviations are used to indicate the comparative rarity or abundance of the species at each locality, and can only be regarded as approximately correct:—

vc = very common.
c = common.
r = rare.
vr = very rare.

List of Fossils from the Upper Crag (Norwich Crag Series) of Norwich, Beccles, and the Bure Valley.

Spongida.

Cliona celata, *Grant* - -	Ann. N. Hist., ser. 2, vol. iii., pl. xii.	Postwick ?

Foraminifera.

Lagena sulcata, *Walker & Jacob.*	Crag For., Pal. Soc., t. 1., f. 41–43.	Thorpe.
Nodosaria raphanus, *Linn.* -	Crag. For., Pal. Soc., p. 49; D'Orbigny, Ann. Sc. Nat., vii. pl. 10, f. 4.	Thorpe.
Polymorphina lactea, *W. & J.* -	Q. J. G. S., viii., t. 16, f. 14 -	Thorpe.
Polystomella crispa, *Linn.* -	D'Orb., Prod. No. 45 -	Aldeby (vr), Bramerton, Thorpe.
——— (Nonionina) striato-punctata, *Fichtel & Moll.*	Crag For., Pal. Soc., pl. 2, f. 38, 39; Parker & Jones, Arctic Foram. Phil. Trans. vol. 155, p. 402, pl. 14, f. 31–34, pl. 17, f. 60 a b.	Bramerton, Thorpe, Aldeby (vc).
Rotalia Beccarii, *Linn.* -	Q. J. G. S., xxx., 183 -	Aldeby, Thorpe.
——— sp. - - -	- - - - -	Bramerton.
Truncatulina lobatula, *W. & J.*	Parker & Jones, Phil. Trans. 1865, p. 381, pl. 14, f. 3–6, pl. 16, f. 18–20; Ann. N. Hist., ser. 2, vol. xix., p. 21, pl. 10, f. 17–21.	Aldeby, Thorpe.

Molluscoida.

Polyzoa.

(Species undetermined) -	- - - - -	Aldeby, Bramerton.

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Brachiopoda.																		
Rhynchonella psittacea, *Chemn.*	- - -					vr	vr				r	r						
Mollusca.																		
Lamellibranchiata.*																		
Abra alba, *W. Wood*	Syndosmya -		c	?	r	vr	vr		r			r						
—— prismatica, *Mont.*	- - -			c	r													
Anomia ephippium, *Linn.*	- - -		r	c	r	c	r	c			r			r				
——— ———, var. aculeata.	- - -			r		vr												
——— patelliformis, *Linn.*	Placunomia -			vr		r	r											
——— striata, *Lovén*	- - -			r											r			
Astarte borealis, *Chemn.*	A. plana -			r	c	c	r			r	r	r	c	vc	r	c	r	
——— Burtinii, *De la Jonk*	- - -						?											
——— compressa, *Mont.*	A. angulata -	r	r	c	c	c	r	r		c		c		c	c	c	c	
——— elliptica, *Brown*	- - -						?											
——— Galleottii, *Nyst*	A. gracilis -											r						
——— incrassata, *Broc.*	- - -									?								
——— Omalii, *De la Jonk*	- - -						?											A single valve, derivative.—S.P.W.
——— sulcata, *Da Costa*	A. ovalis -			vc‡	vr	r	vr	vr		?	?	r						
Cardita chamæformis, *Leathes*	- - -		vr															

* Those with valves united are marked thus ‡.

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton. Upper Bed.	Bramerton. Lower Bed.	Bramerton. Blake's Pit.	Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
Cardita corbis, *Phil.*	- - -			vr														
Cardium angustatum, *J. Sby.*	- - -														?			[Found at Thorpe, Suffolk.—A. Bell.]
——— edule, *Linn.*	C. edulinum (including var. C. obliquum).	vc	vc	c‡	c	vc	vc	vc	c	vc	vc	vc	c	vc	vc	vc	c	
——— ———, var. umbonatum	- - -																	
——— fasciatum, *Mont.*	- - -			c														
——— Grœnlandicum, *Chemn.*	- - -	r		vr		r	vr	r	r	r	r				?			
——— interruptum, *S. Wood*	- - -		vr															
——— Islandicum, *Linn.*	- - -														vr			Fragments?
——— nodosum, *Turt.*	- - -			c								?						
——— Parkinsoni, *J. Sby.*	- - -											?						
——— venustum, *S. Wood*	- - -																	
Circe minima, *Mont.*	- - -	vr																
Cochlodesma prætenue, *Pult.*	Thracia - -			r														
Corbicula fluminalis, *Müll.*	Cyrena consobrina, C. trigonula.			vr			r				r	r				r		
Corbula contracta?, *Say*	- - -	r		vr			vr											
——— striata, *Walker and Boys.*	C. nucleus -	r	r	vc‡	c	c	r	c		r		c	c		c	c	r	
Cryptodon sinuosum, *Donov.*	- - -			vr														
Cultellus pellucidus?, *Penn.*	- - -			r														
Cyclas cornea, *Linn.*	- - -						vr					vr						
Cyprina Islandica, *Linn.*	Venus æqualis -	c		vc‡	c	c	c	r		c	c	c	c	vc	c	vc	c	

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Diplodonta astartea, *Nyst.*	- - -						vr	vr				r						
——— dilatata, *S. Wood*	- - -																	
Donax vittatus, *Da Costa*	D. anatinus			c‡			?				r				r		r	Bramerton, horizon not known.
Hinnites Cortesyi, *De France*	H. Dubuissoni											?						? derived (Lyell).
Kellia, see Scintilla	- - -																	
Lasæa intermedia, *S. Wood*	- - -			vr														
Leda lanceolata, *J. Sby.*	- - -						vr	vr										
—— myalis ?, *Couth.*	- - -										r							
—— oblongoides, *S. Wood*	L. limatula	r	c	c‡	c	c	c	c			c	c	r	c	r	r	r	
—— pernula, *Müll.*	Nucula oblonga		vr								r							Bramerton and Postwick (S.W.).
Lepton nitidum, *Turton*	- - -		c	r‡			r	vr										
Loripes divaricatus, *Linn.*	Lucina - -		r	vr	r		r	c				r						
Lucina borealis, *Linn.*	L. mitis, L. antiquata.	c	r	vc‡	c	c	r	vc	c	r	c	c		r	r	r	r	
Lucinopsis undata, *Penn.*	- - -			vr														
Mactra* arcuata, *J. Sby.*	- - -		?								r							
——— ovalis, *J. Sby.*	M. dubia	c	vc	vc‡	r	r	vr	c	?	c	vc	vc			c	c	c	
——— solida, *Linn.*	- - -			r	r	c	vc	c				r		r				
——— stultorum, *Linn.*	M. magna						r				r							
——— subtruncata, *Da Costa*	M. cuneata	c	c	r	r	c	vc				r	c		r				
Modiola modiolus, *Linn.*	- - -			r	r					?	r	r						
Montacuta bidentata, *Mont.*	- - -			r														
——— ferruginosa, *Mont.*	- - -			c														

* The *Mactra triangularis* figured by S. Woodward (Geol. Norfolk) is not known. *See* Wood, Crag. Moll., vol. i., p. 249.

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Mya arenaria, *Linn.* - -	M. subovata, M. lata.	c	c	vc‡	r	c	c	vc	c	c	c	c	c	c	c	c	c	
—— truncata, *Linn.* -	- - -			vr‡	?		c				r						r	
Mytilus edulis, *Linn.* - -	M. alæformis, M. antiquorum.	vc	c	c‡	c	vc	vc	vc	c	vc	c	vc‡		c	c	vc	c	
Nucula Cobboldiæ, *J. Sby.* -	- - -		r	c	vc	r	r	c			c	r		r	r	r	r	
—— nucleus, *Linn.* -	- - -					vr												
—— tenuis, *Mont.* - -	- - -		r	c‡	r	r	r	c			r			r				
Ostrea edulis, *Linn.* - -	- - -						vr					vr						
Panopea Norvegica, *Spengler*	- - -						vr											
Pecten Gerardii, *Nyst* -	- - -																	Bramerton ?
—— opercularis, *Linn.* -	P. sulcatus, P. reconditus.		r	c	c	r	vr	c		c		c				r		
—— princeps, var. pseudo-princeps, *S. Wood.*	- - -						vr‡					vr						‡ Entire.
—— pusio, *Pennant* -	- - -											vr						
—— tigrinus, *Müll.* -	- - -			r‡		vr					vr			r*				* Var. lævis.
Pectunculus glycimeris, *Linn.*	P. variabilis -		vr				vr	c	r	r		r						
—— sp. - -	- - -			vr														Probably derived. (S. V. Wood.)
Pholas crispata, *Linn.* .	- - -						?	?		r	r				r			
Pisidium amnicum, *Müll.* -	- - -		vr				vr					vr						
—— pusillum, *Turt.* -	- - -						vr											
Saxicava arctica, *Linn.* -	- - -			c		r	r	r										

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Saxicava arctica, var. rugosa, *Linn.*	- - -		r	r		r	r					r			r			
Scintilla ambigua, *Nyst* -	Kellia - -			vr														
Scrobicularia plana, *Da Costa*	S. piperata, Trigonella.	vr	c			vr	vr	vc				r			r		vr	
Solen ensis, *Linn.* - -	- - -			vr‡														
—— siliqua, *Linn.* - -	- - -		c		?		r	r				r						
Sphenalia substriata, *Mont.* -	Montacuta -			r														
Tapes aureus, *Gmel.* - -	- - -						vr	×										
—— texturatus, *Lam.* -	- - -							×										
—— virgineus, *Linn.* - -	- - -						?	×										
Tellina Balthica, *Linn.* -	T. solidula -												c	c	vc	c*		* Pit near Anchor Inn.
—— crassa, *Gmel.* - -	T. obtusa -						?			vr	r	c						Bramerton.
—— fabula, *Gronov.* -	- - -		vr	vr			vr	vr									vr	
—— lata, *Gmel.* - -	T. calcarea, T. proxima, T. ovata, T. ovalis.	r		vc‡	r	c	vc	vc		c	c	c	r	r	r	r	r	
—— obliqua, *J. Sby.* -	- - -	vc	c	vc‡	c	vc	vc	vc	c	vc	vc‡	vc‡		vc	vc	vc‡	c	
—— prætenuis, *Leathes* -	- - -	c	c	c‡	c	c	vc	vc		vc	vc‡	vc		c	vr	c	r	
Thracia papyracea, *Poli.* -	T. phaseolina, Anatina.			c		r	vr								r			
—— inflata, *J. Sby.* -	- - -																	Bramerton.
Venus fasciata, *Da Costa* -	- - -						r	c				r						

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton. Upper Bed.	Bramerton. Lower Bed.	Bramerton. Blake's Pit.	Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
Venus ovata, *Pennant* -	- - -			vc‡														
Gasteropoda.																		
Actæon Noæ, *J. Sby.* -	- - -										r							Norwich (S.W.)
—— tornatilis, *Linn.* -	Tornatella -			r	r		r	vr			r							
—— ——, var. subulatus, *S. Wood.*	- - -																	Bramerton.
Assiminia Grayana ?, *Leach* -	- - -							vr										
Buccinum Dalei, *J. Sby.* -	- - -						vr				vr							
—— undatum, *Linn.*, var. tenerum, *Sby.*	? B. cyaneum -	r				c	r	r	r		c	r			r		r	
Bulla Regulbiensis, *Adams* -	B. obtusa, B. minuta, Cylichna obtusa.			vr		vr	r	vr			r							
—— truncata, *Adams* -	- - -			vr														
—— truncatulus, *Brug.* -	Utriculus -		r															
—— sp. - - -	. - -				r													
Calyptræa Chinensis, *Linn.* -	C. Sinensis, Infundibulum clypeum.		r	r	r		r	r	c		r							
Cancellaria viridula, *Fab.* -	Admete - -						vr											

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Capulus Ungaricus, *Linn.* -	Pileopsis, Sigaretus similis.			vr			vr											
Carychium minimum, *Müll.* -	- - -							vr										
Cassidaria bicatenata, *J. Sby.*	Cassis - -						?					?						
Cerithiopsis tubercularis, *Mont.*	- - -						vr											
Cerithium derivatum, *S. Wood*	- - -						vr											
——— Greenii ?, *Adams* -	- - -					vr												
——— tricinctum, *Broc.* -	C. punctatum -	c	vc	vr	r	c	c	r			c	c					r	
Chemnitzia internodula, *S. Wood.*	- - -		r				vr	vr	c									
——— ———?, var.	- - -						vr											
ligata, *S. Wood*																		
——— nitidissima ?, *Mont.*	- - -		vr															
——— plicatula ?, *Broc.*	- - -		vr															
——— sp. - -	- - -			vr														
Chiton strigillatus, *S. Wood* -	C. octovalvis -											?						
Clavatula, see Pleurotoma -	- - -																	
Columbella ? sulcata, *J. Sby.*	- - -																	Bramerton.
Conovulus, *see* Melampus -	- - -																	
Cypræa Europæa, *Mont.* -	Trivia - -											vr						
Dentalium coarctatum, *Lam.* -	- - -		r															
Eulimene pendula, *S. Wood* -	Paludestrina ? -											vr						M.P.G.

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Table showing the distribution of the Upper Crag Mollusca.

| Mollusca. | | |

Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Melampus fusiformis, *S. Wood.*	M. myosotis, Drap.			vr			?	r			?							Aldeby (C. Reid).
——— pyramidalis, *J. Sby.*	- - -				r		r	r			r	r	r					Bramerton, horizon unknown.
Murex erinaceus, *Linn.* -	- - -						?											
Nassa Cuvieri, *Payr.* -	N. pusillina -		c				vr	r	r									
—— incrassata, *Müll.* -	- - -					vr	r	r				r						
—— propinqua, *J. Sby.* -	- - -						vr											
—— reticosa, *J. Sby.* -	- - -										r	r						
Natica Alderi, *Forbes* -	- - -		r															
——— catena, *Da Costa* -	N. monilifera -	c			r	c	vc	c			c	?		?	r	r	r	
——— catenoides, *S. Wood.* -	N. glaucinoides -							?			?	?						(S.W.)
——— clausa, *Brod. and Sby.*	- - -			vc	r	r	c	c	r	?		r	r				r	
——— Grœnlandica, *Beck.* -	N. pusilla, N. borealis.			r			vr											
——— helicoides, *Johnson* -	- - -	r		r		vr	vr	r	r						r	r	c	
——— sp. - - -	- - -		r															
Odostomia conoidea, *Broc.* -	- - -						vr		r									
——— ? derivata, *S. Wood.*	- - -						vr											
——— plicata, *Mont.* -	- - -											vr						M.P.G. Bramerton ?.
Ovula Leathesii, *J. Sby.* -	- - -																	
Paludina ? glacialis, *S. Wood.*	- - -												vr		r	vr		
——— media, *Woodw.* -	P. lenta, P. obsoleta, P. rotundata, P. parilis.	r					vr		r	r	r	r						

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.		Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	M.P.G.
						Upper Bed.	Lower Bed.	Blake's Pit.									
Paludina tentaculata, *Linn.*	Bithynia						vr	vr				vr					
—— viviparæ, *Linn.*	-																
Patella vulgata, *Linn.*	-						vr										
Planorbis complanatus, *Linn.*	P. marginatus, Drap.						vr	vr									
—— spirorbis, *Mull.*	-															vr	
—— sp.	-																
Pleurotoma bicarinata, *Couth.*	Mangelia, Defrancia			vr			vr										
—— harpularia, *Couth.*	-																
—— linearis, *Mont.*	Clavatula			vr						?							
—— mitrula, *J. Sby.*	Clavatula										?						
—— rufa, *Mont.*	-															r	
—— Trevelyana, *Turt.*	Clavatula						vr	?									
—— turricula, *Mont.*	Bela, Murex punctatus.	r	c			vr	r	r			r					r	
Pupa edentula, *Drap.*	Vertigo							vr									
—— muscorum, *Mull.*	P. marginata						vr	vr									
Purpura lapillus, *Linn.*	P. crispata, Murex bulbiformis, &c. *See* Woodward, Geol. Norf., pp. 44, 45.	vc	c	r	r	c	vc	vc	c	c	vc	c		c	c		
—— – ——, var. incrassata, *J. Sby.*	-									?							

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Table showing the distribution of the Upper Crags Mollusca.

Mollusca.		Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton.			Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
						Upper Bed.	Lower Bed.	Blake's Pit.										
Ringicula buccinea, *Broc.*	- - -			?														
—— —— ventricosa, *J. Sby.*	- - -		c	vr	c	vr	r	r	r									
Rissoa curticostata, *S. Wood.*	R. ringens, Auricula						vr	vr										
	R. (Turbo) semicostata, R. pulchella, R. inconspicua ?.																	
—— proxima, *Alder.*	- - -						vr											
—— striata, *Mont.*	- - -						vr											
Scalaria clathratula, *Adams*	S. minuta -									r		vr						
—— Grenlandica, *Chemn.*	S. similis -	r		r		r	c	r	r		r	r		r	r		r	
—— Trevelyana, *Leach*	- - -		r	r			r	vr	r	r								S. V. Wood.
—— Turtoni, *Turton*	- - -		r				vr	vr								vr		
Succinea putris, *Linn.*	- - -						vr	vr										
Textura? parvula, *S. Woodw.*	Patella -						vr											
—— virginea, *Müll.*	Acmæa -						vr											
Tornatella, *see* Actæon	- - -											r						
Trochus granulatus, *Born.*	T. noduliferens ? -						vr					r						Bramerton.
—— noduliferens, *S. Wood.*	T. papillosus, T. minuta,																	
—— tumidus, *Mont.*	T. nitens -		r	c	r	r	r	r	r	r		r						
—— zizyphinus, *Linn.*	- - -						vr	vr										
Trophon Actoni, *S. Wood.*	Fusus -						r											
—— altus, *S. Wood.*	Murex pullus -						r				r	r						(S.W.)
—— antiquus, *Linn.*	Fusus despectus, Murex striatus. -	r	r	r	r	r	c	c		c	c	c	r	r	r	c	r	

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Table showing the distribution of the Upper Crag Mollusca.

Mollusca.	Ditchingham.	Beccles.	Aldeby.	Brundall.	Bramerton. Upper Bed.	Bramerton. Lower Bed.	Bramerton. Blake's Fit.	Kirby Bedon.	Whitlingham.	Postwick.	Thorpe.	Rackheath.	Wroxham.	Belaugh.	Coltishall.	Horstead.	—
Trophon antiquus, var. contrarius.	r		r		r	c			r	r	r	r	vr	r		r	Aldeby (S.V.W.).
—— Berniciensis, *? King* - T. Spitzbergensis?										r							
—— gracilis, *Da Costa*	vr									r							
—— scalariformis, *Gould*	?					vr	r				r						
Turritella incrassata, *J. Sby.*	c				r	c	c	c	c	c	c				r		
—— terebra, *Linn.* - T. communis	r	c	r	r	r	c	c	c	c	r	c				r		
Utriculus, *see* Bulla						vr											
Valvata cristata, *Müll.*					vr	vr											
—— piscinalis, *Müll.*						vr				r	r						
Velutina lævigata, *Penn.*						?											
—— undata, *J. Smith*																	
Vertigo, *see* Pupa																	
Voluta Lamberti, *J. Sby.*	vr																Bramerton, horizon unknown. Norwich.

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ECHINODERMATA.		
Echinoidea.		
Echinocyamus pusillus, *Müll.* -	Forbes, Tert. Ech., Pal. Soc., t. 1, f. 8–15.	Beccles.
——— Suffolciensis, *Ag.*	Forbes, t. 1. f. 16 - -	Beccles.
Echinus (Spines) - -	- - - - -	Aldeby, Bramerton, Kirby Bedon.
ANNELIDA.		
Serpula - - -	- - - - -	Bramerton.
Annelid borings - -	- - - - -	Postwick (Brit. Mus.).
CRUSTACEA.		
Entomostraca.		
Cythere macropora, *Bosq.* -	Mem. Acad. Belg. xxiv., p. 97.	Aldeby.
Cirripedia.		
Balanus bisulcatus? *Darwin* -	Mon. Cir., Pal. Soc., t. 2, f. 2	Thorpe.
——— crenatus, *Brug.* -	B. rugosus, Mont.? B. balanoides; Mon. Cir., t. 1, f. 6, a–g.	Bramerton, Postwick, Thorpe, Brundall, Aldeby.
——— dolosus, *Darwin* -	Mon. Cir., p. 28, t. 2, f. 3, a–d.	Postwick.
——— porcatus, *Da Costa* -	B. tessellatus, Mon. Cir., t. 1, f. 5 a–g.	Bramerton, Thorpe, Aldeby.
——— sp. - - -	- - - - -	Aldeby, Bramerton, Belaugh, Ditchingham.
Decapoda.		
Carcinus mænas, *Penn.* -	Malac. Podop. Brit., t. 5, f. 1–4.	Bramerton.
——— sp. - - -	- - - - -	Bramerton, Thorpe, Brundall, Beccles.
PISCES.		
Acipenser - - -	- - - - -	Bramerton (S.P.W., ms.).
Carcharodon - - -	*Carcharias* (W. H. Flower)	Thorpe (R.F.), Aldeby (Crowfoot & Dowson).
Esox - - - -	Pike teeth - - -	Bramerton (J. de Caux).
Myliobatis - - -	Derived? - - -	Norwich (Lyell, Mag. Nat. Hist. 1839, p. 318).
Notidanus microdon, *Ag.* -	Dixon, Foss. Suss., t. 30, f. 30.	Thorpe (R.F.).
Platax Woodwardi, *Ag.* -	Poiss. Foss., 3, t. 37, f. 33 -	Bramerton (J.R.), Aldeby (Crowfoot & Dowson), Thorpe (R.F., M.P.G.).
Raia antiqua, *Ag.* - -	Poiss. Foss., 4, t. 19, f. 3 -	Thorpe (R.F.), Bramerton (J.R.), Beccles (W.M.C.), Aldeby (Crowfoot & Dowson).
Zygobates? - - -	- - - - -	Thorpe (R.F.).
Elasmobranch and Teleostean vertebræ, Otolites, Palatal teeth, &c.	- - - - -	Thorpe (R.F.), Whitlingham, Wroxham, Brundall (M.P.G.), Beccles (W.M.C.), Ditchingham (C. Reid), Bramerton (J.R.), Aldeby (Crowfoot & Dowson).
AVES.		
Uria troile, *Linn.* - -	Guillemot (W. H. Flower)	Aldeby. (Crowfoot Dowson).
Bird's (humeri) - -	- - - - -	Thorpe (R.F.).

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MAMMALIA.

Arvicola intermedius, *Newton* -	Geol. Mag., Dec. II., vol. viii., p. 258.	Bramerton (J.R.), Thorpe (R.F.).
Balænodon - - -	Whale - - -	Bramerton or Whitlingham (R. C. Taylor, Geol. E. Norf., p. 14), Aldeby.
Bison or Bos - - -	- - - - -	Thorpe (R.F. *Bos.**) Stoke Holy Cross (M.P.G.).
Cetacean (vertebra) - -	- - - - -	Thorpe (M.P.G.).
Capra ? - - -	- - - - -	Thorpe (M.P.G.).
Cervus ardeus, *Croizet & Jobert*	- - - - -	Thorpe (R.F.*).
——— elaphus, *Linn.* - -	Owen, Foss. Mam. f. 196† -	Thorpe, Postwick (R.F.).
——— Falconeri, *Dawk.* -	Q. J. G. S., xxiv., t. 18, f. 9-12.	Thorpe (R.F.*).
——— Suttonensis, *Dawk.* -	Q. J. G. S., xxxiv., f. 7-10, p. 412.	Horstead (J.G.).
——— sp. - - -	Fragments - - -	Stoke Holy Cross, Thorpe, Whitlingham (M.P.G.), Aldeby (Crowfoot & Dowson), Horstead (R.F., M.P.G.).
Delphinus - - -	Dolphin (W. H. Flower) -	Aldeby (Crowfoot & Dowson).
Elephas antiquus, *Falc.* -	A. L. Adams, Pal. Soc. -	Horstead (J.G.), Thorpe (R.F.).
——— meridionalis, *Nesti* -	*Idem.* - - -	Thorpe (R.F.*), Horstead (J.G., R.F.).
——— sp. - - -	Fragments - - -	Bramerton, Thorpe (M.P.G.), Aldeby (Crowfoot &Dowson)
Equus caballus fossilis, *Rütim* -	Owen, Foss. Mam. f. 142, 143.†	Thorpe (R.F., *E. plicidens?** M.P.G.), Whitlingham (M.P.G.).
——— sp. - - -	Fragments - - -	Horstead (J.G.), Aldeby (Crowfoot & Dowson).
Felis pardoides, *Owen* - -	Foss. Mam. f. 66† - -	Thorpe (R.F.*).
Hippopotamus, sp. - -	- - - - -	Norwich (R.F., R. C. Pitt).
Hyæna antiqua, *Lank.* -	Ann. Nat. Hist., ser. 3., vol. xiii., Pl. viii.†	Thorpe (R.F.*).
Lutra - - - -	- - - - -	Thorpe (R.F.*).
Mastodon arvernensis, *Croizet & Jobert.*	*M. angustidens*, Owen Foss. Mam., f. 97-101; Falconer, Q. J. G. S., vol. xiii., Pl. xii.	Thorpe (R.F.,*M.P.G.), Horstead (Rev. J. Layton, S.W., J.G., R.F.), Surlingham (J.G.), Whitlingham (W. Smith), Postwick (R.F., R. Wigham).
——— - - -	Fragments - - -	Bramerton (H. Alexander, S.W.), Coltishall (Prestwich), Poringland (J. T. Todd), Saxlingham Nethergate.
Phoca, sp. - - -	Humerus (identified by Prof. Flower).	Bramerton (found by J. E. Taylor in "sand "beneath the Chilles-"ford Clay," J.Gunn).
Trogontherium Cuvieri, *Fischer*	Owen, Foss. Mam., f. 71-73†	Thorpe (R.F.*).
Ursus - - - -	- - - - -	Thorpe (R.F.*).
Bones (indeterminable) -	- - - - -	Hartford Bridges (M.P.G.).
Rodent - - -	- - - - -	Aldeby, Bramerton, Thorpe.

* List given by J. Prestwich, Q. J G. S., vol. xxvii., p. 456.
† These are references to figures of *specimens* not obtained from the Norwich Crag.

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The following species of Mollusca recorded from the Crag of "Norwich" are doubtful:—*Abra obovalis*, S. Wood; *Artemis linota*?, Pult.; *Cardita scalaris*, Leathes; *Cytherea rudis*, Poli; *Diplodonta rotundata*, Mont. (Mus. Pract. Geol.); *Glycimeris angusta*, Nyst.; *Leda semistriata*, S. Wood; *Bulla alba*, Brown (*Cylichna cylindracea*); *Chemnitzia elegantissima*, Mont. (*C. elegantior*); *Erato lævis*, Don.; *Helix hispida*, var. *plebeium*, Drap.; *Litorina tenebrosa*, Mont.; *Margarita grœnlandica*, Chemn. (*M. undulata*); *Natica hemiclausa*, J. Sby.; *Purpura tetragona*, J. Sby.; *Rissoa confinis*, S. Wood; *Scalaria foliacea*, J. Sby.; *Trophon Gunneri*, Lovén; *T. Norvegicus*, Chemn.

Several Mammalia have also been recorded from the Norwich Crag, that require confirmation. Among these are *Arvicola campestris*, *A. arvalis*, *A. agrestis*, *Canis vulpes*, *Lepus cuniculus*, *Sus scrofa*, and the Elk.

Mr. Gunn informs me that the Fox was identified in the late Mr. Middleton's collection by Dr. S. P. Woodward. The Rabbit was recorded in the Norfolk News, January 7, 1871. The Pig was mentioned by Lyell, Mag. Nat. Hist., 1839, p. 318, and Proc. Geol Soc. vol. iii., p. 128; also by Mr. Gunn, Norwich Mercury, 1866. The Elk was mentioned by Mr. R. C. Pitt, Proc. Sci. Soc. London, vol. ii., p. 4. The Beaver (*Castor Europæus*) has been recorded from the "fluvio-marine crag at Thorpe, in Suffolk." (Owen, Foss. Mam. p. 191).

Messrs. A. and R. Bell in their list of fossils from the Upper Crag (Proc. Geol. Assoc., vol. ii., pp. 212 and 271) give no localities, and include in the Upper Crag, the upper part of the Red Crag as well as the Norwich or Fluvio-marine Crag, and exclude the Chillesford series.

The following species not found in the area have been recorded from the Upper (Norwich) Crag of Norfolk and Suffolk:—*Artemis lentiformis*, Sby.; *Cardita borealis*, Conrad; *Cardium strigilliferum*, S. Wood; *Donax trunculus*, Linn.; *Leda pygmæa*, Münst.; *Modiola discors*, Linn.; *M. marmorata*, Forbes; *Pholas candida*, Linn.; *Saxicava fragilis*, Nyst.?; *Unio pictorum*, Linn.; *Aporrhais pes-pelicani*, Linn.; *Buccinum undatum*, Linn., var. *Grœnlandicum*, Ch.; *Chemnitzia rugulosa*, S. Wood; *Cypræa avellana*, J. Sby.; *Eulima polita*, Linn.; *Eulimella acicula*, Phil.; *Natica multipunctata*, S. Wood; *N. occlusa*, S. Wood; *Planorbis corneus*, Linn.; *Pleurotoma Dowsoni*, S. Wood;* *P. pyramidalis*, Ström.; *P. violacea*? Migh. and Adams; *Scalaria pseudo-scalaria*, Brocchi; *Succinea oblonga*, Drap. See also Mr. Reid's Geology of the country around Cromer.

Local Details.

I.—Bure Valley.

Hevingham.—Pebbly gravel has been opened up in several places between the church and Hevingham Street in pits worked partly for Chalk. The following section of the beds is shown south-east of Broom Covert:—

Upper Crag	False-bedded sand and gravel with iron-stone nodules. Blue and brown laminated clay with irregular bed of buff sand near the base, 4 to 5 feet. Sand and pebble gravel and broken flints, 2 feet 6 in. to 3 feet. Chalk with flints.

West of Park Farm pebbly gravel has been dug.

Stratton Strawless.—The occurrence of iron-pan containing casts of shells has been noticed near Stratton Strawless and Marsham, by Messrs. R. Fitch and T. G. Bayfield.†

A section at the lime-kiln, in the valley opposite to Broom Covert, showed the Upper Crag, consisting of pebbly gravel with seams of clay, resting on the Chalk and covered by stony loam (Lower Glacial).

Buxton.—The railway cuttings exposed pebbly gravel and sand. These beds may be seen resting on the Chalk in a pit north of the old workhouse.

Lammas.—Several pits have been opened in pebbly gravel, and the junction of these beds with the Chalk may be seen east of the church.

Hautboys.—A pit north of Hautboys Hall displayed irregular beds of sand and gravel resting on the Chalk. Between the Hall and Mayton Bridge the railway-cutting showed a loamy surface soil, resting on the pebbly sands.

* This species, I am informed by Mr. Dowson, was found at Reydon, near Southwold, not at Aldeby, as recorded by Mr. S. V. Wood.

† Norwich Geol. Soc., Norfolk News, Sept. 9, 1871.

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Three or 4 feet of Chalk was exposed by the bridge. East of the bridge and above the Chalk (which extended but for a short distance in the cutting) was seen the stone-bed, capped by sands, seams of laminated clay, and pebbly gravel, altogether about 10 feet in thickness.

South of the letters *ut* of Great Hautboys (on the map) a pit showed the following section:—

Upper Crag	Red gravel	4 feet.
	Laminated clay and white sand	10 „
Chalk.		

Mayton.—A pit west of Mayton Hall showed 15 feet of sand and fine gravel resting on a very irregular surface of the Chalk.

Horstead.—The Crag has been very largely opened up in the parish of Horstead on account of the numerous excavations for Chalk.

The very picturesque canals that intersect the district south of Haggard Street bear witness to the amount of Chalk that has been removed, and as this was worked away the Crag or "uncallow" was tipped over the lost ground. The last working was closed in 1877, and the ground being sloped and planted with fir trees, little will remain for the geologist. The beds exposed were:—

Warp	12 feet.
Gravel with patches of comminuted shells	
Laminated clays, sands and gravel	
Chalk.	

The only specimen I obtained during the progress of the Geological Survey was a portion of a deer's horn; but in 1866 (when on a visit with Mr. Gunn) I obtained *Astarte borealis* and *Tellina prætenuis*. Trimmer, who described a pit in this district, mentioned one seam of Crag as 10 feet in length, and as yielding *Astarte borealis*, *Cyprina Islandica*, and *Tellina obliqua*.* The list of species (see p. 42), is on the authority of specimens obtained by Mr. S. V. Wood, Mr. J. Reeve, and myself. Horstead has always been noted as the sepulchre of many remains of Mastodon, and particularly of an entire skeleton which has been mentioned by several writers. It has also been reported that the entire skeleton of an Elephant,† even that two skeletons of the Elephant were found at Horstead;‡ but I am disposed to think that the evidence is confined to the one discovery made known by the Rev. James Layton, of Catfield. His remarks are embodied in a book entitled "A General View of the Geology of Scripture," by George Fairholme, Esq. (1833), from which work the following statements are extracted (pp. 283, 369–371).

"In 1820, an entire skeleton of the Great Mastodon was found at Horstead, near Norwich, lying on its side, stretched out, *between the chalk and the gravel.* A grinder was brought to me (it is still in the possession of Dawson Turner, Esq., of Yarmouth), but so long after it was discovered, that scarcely any other part of the animal could be preserved. The whole had been carried away with the chalk, and burnt for lime, or spread in minute fragments over the fields.

"Being desirous of ascertaining upon what certain grounds this skeleton was called that of the Great Mastodon, I wrote to Mr. Layton to request some further explanation on the subject, and in reply, I had the pleasure of receiving the following interesting statement:—

"I lived at Catfield, in Norfolk, 6 miles from Hasborough, and about as far from Horstead. From this latter place, marl (*soft chalk with regular layers of flint, about 4 feet apart, or less*) is carried to all the villages in the neighbourhood, to be spread upon the lands. A boatman, who was in the habit of bringing me fossils, brought a grinder of this Mastodon as a curiosity, saying it had been found in the marl, and given to him by the head pitman. It was the posterior portion of the grinder of the great Mastodon (I am certain of the fact), containing, as far as I recollect, eight points, none of which had been

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* Quart. Journ. Geol. Soc., vol. i., p. 312.

† *See* Trimmer, Quart. Journ. Geol. Soc., vol. i., p. 312.

‡ S. Woodward, MS. 1825; copy of letter to Mr. W. Pightling, Coltishall, dated 9 May 1827; *see also* Mag. Nat. Hist., vol. ix., p. 151.

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cut, or brought into use. On the first opportunity, I went to make inquiry about it at the Chalk pit. The pitman pointed out to me the place where it was found, and said, that the *whole animal was*, as it were, *lying on its side, stretched out on the surface of the marl*. He described it as being very soft, and that a great part of it would at first *spread like butter*; the whole, however, had been thrown down along with the marl, and carried away. He said, he had looked upon it as *very curious* indeed, but *of no use*, and he had kept that piece of the tooth merely by accident. He afterwards found another fragment or two of the bones, in his garden, where he had thrown them, and he sent them to me. They are now in my possession, but I am not able to identify them with the *Mastodon*, as distinguished from the *Mammoth*, or Elephant. The grinder, I sent to Dawson Turner, Esq., of Great Yarmouth, who probably has it now."

I have inserted this passage in full because it furnishes presumptive evidence that a considerable portion of the skeleton of a Mastodon was obtained in the Crag at Horstead. Mr. Gunn has also added further testimony to the above statements, which it seems desirable to reprint as some discredit has been thrown on the subject.* His remarks are as follow:—

"The fact that a large portion of the skeleton was found with the tooth was considered by Dr. Falconer to be of importance, as a proof that the animal lived near where its remains were found.

"With a view to ascertain the particulars of the discovery of these interesting remains I went with Dr. Hooker to Horstead to make inquiry. Although 15 or 16 years had elapsed, we met with Mr. Collins, who was then, at the time of the discovery, the lessee of the marl-pits. He took us to the very spot where the remains had been exhumed, and confirmed the report that a great many bones were found, together with the tooth, but could not say that there was the entire skeleton. They were lying immediately upon the surface of the chalk, and the spot was about 300 yards on the left side from the bridge over the canal (commonly called Little Switzerland)."†

In this, as in other localities where fossils have been found, some of the pits show no traces of any organic remains whatever. Such was the case with the following section seen in a pit by the valley south of Burnt Lane plantation:—

		ft.	in.
Upper Crag	Pebbly gravel and sand	5	0
	Laminated clay	0	3
	Sand	0	6
	Gravel	0	6
	Laminated clay and sand	1	0
	False-bedded sand and gravel with large flints	3	6
Chalk.			

Many years ago several pits were opened in what is now the plantation west of Horstead Water-mill. They are mentioned by old writers, one of whom says, "There is a Bed of these Cockle-shells at Horstead in Norfolk, in a Gravel "Pit, in a rising Ground, near the River, by the Mill."‡

S. Woodward also says (in writing of an excursion made in October 1830), "Crossing over to Horstead Mill, I found traces of the Crag in both the Pits "on each side of Mr. Coll's House, about 30 feet above the level of the River."

The lane cutting a little further south, and which was first pointed out to me by Mr. Gunn, shows a bed of shells yielding the following species:—

Litorina litorea.	Cyprina Islandica.
Limnæa peregra.	Mya arenaria.
Natica helicoides.	—— truncata.
Planorbis.	Mytilus edulis.
Astarte compressa.	Nucula Cobboldiæ.
Cardium edule.	Tellina obliqua.

* F. W. Harmer, Quart. Journ. Geol. Soc., vol. xxxiii., p. 139; *see also* H. B. W., Proc. Norwich Geol. Soc., vol. i., p. 18.

† Meeting of the Norwich Geol. Soc., April 6, 1875, reported in the "*Norfolk News*." *See also* E. R. Lankester, Quart. Journ. Geol. Soc., vol. xxvi., p. 497.

‡ Dr. T. Burnet. *De* Statu Mortuorum et resurgentium *tractatus*. 2nd edition. By M. Earbery. 2 vols. 1728. Vol. ii., p. 46.

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West of Horstead Church is a large deserted pit with canal communication. Here, when in company with Mr. Gunn, he obtained a few shells. A little further west another pit showed :—

		Feet.
Upper Crag	Pebble gravel with large flints and shells	4 to 5
	Laminated clay	3
	Sand and gravel	3
	Stone bed, rolled flints and pebbles	
Chalk.		

This is no doubt the section referred to by Prof. Prestwich, when he says "At Horstead the Westleton shingle with crag-shells overlies the Chillesford "Clay."*

South of Stewpond Car a pit showed :—

Upper Crag	Sand and pebble gravel	3 to 4
	Laminated clay (irregular)	2
	Sand and gravel with shells	3 to 4
	Stone bed and white sand	
Chalk.		

In both sections the following species occurred :—

Litorina litorea.	Mya arenaria.
Cardium edule.	Tellina obliqua.
Cyprina Islandica.	

Between Stewpond Car and Horstead Hall a pit showed 8 feet of pebble-gravel containing boulders of quartz and large flints.

Coltishall.—One of the best sections of the Crag is that seen a little to the south-east of the Railway station, where not only the Chalk is worked, but a laminated clay in the Crag series is obtained for making bricks.

The section has varied very considerably since I first visited it. One conspicuous feature was a tongue of sand, which divided up the laminated clay in the part of the pit worked, and whose lower junction with the clay would, if isolated, have been taken for an unconformity between the "Chillesford Clay" and overlying sand. The gravel above also rested in one place on an eroded surface of the clay beneath: an erosion which may have been caused by springs in recent times. The clay itself becomes more and more interbedded with sand, until in one place it is but a subordinate feature. The following is the section, which was taken in 1877 (See Plate II., fig. 4.) :—

	Feet.
4. False-bedded pebble gravel and sand	9 to 12
2. Laminated clay with bed of sand (3)	6 to 6½
1. False-bedded sand, gravel, and shell-beds (*s*) with seams of clay and clay-pebbles	5
A. Chalk, with flints and paramoudras, about 12 feet exposed.	

A bed made up of specimens of *Mytilus edulis* occurs from 1 to 2 feet above the Chalk: a similar bed occurs at Wroxham.

At one time the shell-bed abruptly terminated in a mass of buff unfossiliferous sand.

Mr. Prestwich, who described this section, mentioned a subordinate bed of iron-sandstone and clay-ochre, 1½ feet thick, in the pebbly gravel ("Westleton Beds"). The clay he classed as "Chillesford Clay," and noticed in it a few fragments of wood and a seam of pebbles.† He observed that, "Teeth and "bones of the Mastodon are occasionally found at the base of the same bed. "One of the workmen informed me that he had also found bones above the "clay." At the time of one of my visits the workmen had obtained from the lower part of the Crag, portions of the humerus of either Elephant or Mastodon, but Mr. E. T. Newton could not determine which.

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* *See* Prestwich, Quart. Journ. Geol. Soc., vol. xxvii., pp. 459, 468.

† Quart. Journ. Geol. Soc., vol. xxvii., p. 459. The traces of Boulder Clay he observed were not visible when I saw the pit.

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The list of species from Coltishall given in the table (p. 41) is partly on the authority of specimens collected by Mr. S. C. Sothern and myself, and partly on those enumerated by Mr. S. V. Wood, Prof. Prestwich, and Mr. James Reeve.*

Tellina Balthica and *Helix arbustorum* were obtained in the pit near the Anchor Inn, and have not been found in the bed exposed near the Railway-station. All the other species enumerated from Coltishall were obtained from the last-named pit.

The pit near the Anchor Inn has yielded several species, but the section is very obscure, and my colleagues Messrs. Blake and Reid, and myself came to the conclusion that the portion of the pit now worked, was opened in re-assorted material, discarded as the Chalk had been worked away. The following species have been obtained:—

Helix arbustorum.
†Litorina litorea.
†Limnæa palustris.
Astarte borealis.
†Cardium edule.
†Cyprina Islandica.
†Mya arenaria.
†Tellina Balthica (very abundant).
—— obliqua.

The cuttings in the railway in Coltishall parish all showed buff false-bedded sand and pebbly gravel, with many veins and nodules of ironstone, capped by a little brickearth (Lower Glacial) at the Station.

The foundation for the bridge by the Station, opened up 10 feet of pebbly gravel, capped by brickearth belonging to the (Lower Glacial) Contorted Drift, the junction between which was irregular. Immediately west of this bridge, and about the level of the railway, a bone (indeterminable) was obtained. Another one, identified by Mr. E. T. Newton as the *os magnum* of an Elephant or Mastodon, was found in pebbly gravel near the goods shed of the Coltishall Station, and kindly presented to me by the Station-master.

Belaugh.—Shells are met with in an excavation by the side of the hill, near the Farm buildings, about a quarter of a mile north-west of the church. The following is the section, the lower part of which was opened up in 1877 by Mr. Gunn, Mr. J. H. Blake, Mr. C. Reid, and myself:—

		Feet.
Upper Crag	Pebbly sand	10 or 12
	Brown pebbly sand with shells	3 to 4
	Sand	4½ to 5
	Laminated clay and sand	½
	Stiff brown and blue clay	1
	Sands and clays	3½
	Large flints (? stone bed).	

The Chalk itself in this neighbourhood has been eroded so as hardly to present any actual exposure in the low line of hills bordering the river. Mr. Harmer has stated that the principal shell-bed is from 10 to 15 feet distant from the surface of the Chalk, and that another bed containing a few specimens of *Tellina Balthica* and *Litorina litorea*, and many specimens of *Astarte borealis*, together with *A. compressa*, and *Cyprina Islandica* occurs below.‡ A full list of the species obtained by Messrs. S. V. Wood, F. W. Harmer, J. Reeve, my colleagues, and myself is given in the Table (p. 41).

A pit immediately west of Belaugh Old Hall showed the following section:—

		Feet.
Upper Crag	Pebbly sands	8 to 10
	Laminated clay	4 to 5

Chalk with flints, and with tolerably even surface.

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* Crag Mollusca, and Quart. Journ. Geol. Soc., vol. xxvii., p. 459.

† These species were recorded by Mr. Prestwich, Quart. Journ. Geol. Soc., vol. xxvii., p. 468.

‡ Norwich Mercury, March 10th, 1869; Geol. Mag., vol. vi., p. 233.

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I was unable to map out the continuation of this clay with that at Hoveton; possibly they are on the same horizon, but from the variable nature of the beds they may be distinct.

By the Wood, S.E. of the Old Hall, about 20 feet of sand and gravel, with traces of laminated clay at the base, were to be seen resting on the Chalk.

At Belaugh Green, a pit showed 4 feet of sand and laminated clay much disturbed, capped by 3 feet of brown clay (Contorted Drift), resting apparently in a pocket of the older beds.

Horsham St. Faith's.—A pit south of Waterloo showed 18 feet of pebbly gravel and sand, with pebbles of quartz, flint, and quartzite. Beneath was wet marly chalk passing down into the solid Chalk. The gravel was overlaid by 4 feet of stony loam (Lower Glacial).

Spixworth.—A section in the valley, by the road running between Crostwick and Spixworth, showed the Crag consisting of pebbly gravel and sand, resting on the Chalk. The basement beds included traces of laminated clay and a stone bed 1 foot in thickness.

The following list of shells includes those recorded by Mr. S. V. Wood and those obtained by myself:—

Astarte borealis.	Mya arenaria.
Cardium edule.	Tellina Balthica.
Cyprina Islandica.	——— obliqua.

Haynford.—North-west of Spixworth Bridge there is 10 to 12 feet of pebbly gravel and sand, with seams of laminated clay.

Frettenham.—Pits on Frettenham Common show sand and pebbly gravel, part of which I was at first disposed to group as Glacial. The beds, however, rest on the Chalk and appear to be covered to the north by stony loam (Lower Glacial) of very irregular thickness.

Crostwick.—The pits on Crostwick Common are too much overgrown and obscured to show any section now.

Mr. R. C. Pitt, however, recorded the following section of the Crag at Crostwick* :—

20 feet -
- C.—Accumulation of several patches of crag, some of which are highly coloured with oxide of iron [15 feet].
- B.—Coarse gravel, 4 feet, "valves of *Cyprina Islandica* " and *Nucula Cobboldiæ* in great profusion and in " better preservation than in any other deposit." Bed cemented into hard conglomerate.
- A.—Stratum of shells imbedded in fine yellow sand, 1 foot.

Chalk.

East of the last *e* of White Horse (on the map) 12 feet of pebbly sand, with fragments of shells, was to be seen resting on the Chalk.

About half a mile west of the church a pit showed 10 feet of false-bedded sand and pebbly gravel, resting on 1 foot of flints and clay (Stone bed), then Chalk, much eroded.

The following species have been recorded by Mr. Pitt, Mr. Wood, and Sir C. Lyell:—

Cardium edule.	Mya arenaria.
Corbicula fluminalis (Cyrena trigonula).†	Nucula Cobboldiæ.
Cyprina Islandica.	Tellina Balthica.

Rackheath.—At the lime-kiln, north of the Church, the Crag would at first sight be termed unfossiliferous, but casts of shells are here and there preserved in thin bands of ironstone; the following is the section:—

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* Proc. Scientific Soc., Lond., vol. ii., 1840, p. 3.

† Lyell, Mag. Nat. Hist., new ser., vol. iii., p. 321.

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		ft.	in.
Upper Crag	Pebbly gravel	6	0
	Black ironstone and indurated sand with ironstone nodules, and casts of *Cardium edule* and *Litorina litorea*	0	6
	Yellow sand and gravel	9	0
	Laminated sandy clay, disturbed at top - 1 to	1	6
	Fine buff sand with gravelly seams	1	6
		18	6

Chalk.

Trimmer mentioned that here the surface of the Chalk was marked by broad undulations. At the time he wrote the Crag was more fossiliferous in this particular locality than at present; but several old workings in the neighbourhood, are now entirely concealed with talus and vegetation. He says:

"In the spring of 1844, in the progress of the workings, a bed of Crag shells was exposed, about 3 feet long and 2 feet thick, at the height of about 3 feet above the surface of the Chalk; and another thin layer of Crag shells may be seen in the bank of an adjoining road."*

A second pit, about half a mile distant in Wroxham parish, shows an abundance of shells, while a third a little further seems quite devoid of fossils. A list of species obtained at Rackheath, is given, on the authority of Mr. S. V. Wood, in the table, p. 42.

Near the edge of the pond, south of Chapel Wood, a pit showed 15 feet of false-bedded sand and gravel with laminated clay seams. Portions of the sand were quite black with manganese-ore.

Wroxham.—Fig. 5, on Plate II., represents a pit near Wroxham Park, situated to the east of the Hall, near the farm-buildings. It showed the following section:—

		Feet.
Upper Crag	4. Sand and pebbly gravel	8 to 10
	3. Shell-bed (impersistent), sand and gravel	
	2. Laminated clay and sand	1
	1. Sand and shell-bed	1½

A. Chalk with flints.

Bed No. 2, according to Mr Prestwich, represents "probably, the Chillesford Clay."† I could not hazard such an identification.

In bed No. 1 entire single valves of *Cyprina Islandica* are not uncommon. I have found *Tellina Balthica* abundantly in bed No. 3, but not in bed No. 1, though it is said to occur there.‡

I obtained the following species:—

	Bed 3.	Bed 1.
Litorina litorea	×	×
Natica, sp.	×	
Scalaria Grœnlandica	×	
Astarte borealis	×	×
„ compressa		×
Cardium edule		×
„ „ var. umbonatum	×	
Cyprina Islandica		×
Mya arenaria	×	
Mytilus edulis		×
Tellina Balthica	×	
„ obliqua	×	×

* Quart. Journ. Geol. Soc., vol. i., p. 309.
† Quart. Journ. Geol. Soc., vol. xxvii., p. 468.
‡ Norwich Geol. Soc., Eastern Daily Press, 9th Sept. 1875.

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Shells are found in several places east of Wroxham Hall, and near the farm-buildings.

A pit by the wood between Wroxham Hall and the brickfield (marked on the map) showed:—

		Feet.
Upper Crag	Pebbly sand	4 to 5
	Laminated clays and sands	4 to 5

North of Wroxham Hall a pit showed 12 feet of rather coarse ferruginous flint-gravel, similar to beds opened up by the wood south of Belaugh Broad. These beds have been considered to be Valley Gravel, but they are identical with beds which elsewhere belong to the Crag Series, as in the parish of Woodbastwick, and I have so included them here.

To the west of Wroxham Hall there is a picturesque old pit with a branching canal running up into it, as in the old pits at Horstead. Here shells were formerly found, as I was informed by Mr. Gunn. Passing southwards towards Rackheath Church, we come first to a pit of sand and gravel resting on Chalk, where, after diligent search on several occasions (in one instance in company with Dr. Henry Woodward), I have found no trace of a shell in the Crag. A little further on, the same beds show shells in abundance: here the section is as follows:—

		Feet.
Upper Crag	3. Pebbly gravel with shells up to the surface	6
	2. Laminated clay	½
	1. Shell bed, sand and gravel	2

Chalk with flints.

This is one of the most instructive sections in the Bure Valley: it exhibits the (occasionally) fossiliferous nature of the "Pebbly sands and Pebble beds" ("Bure Valley Beds"), and shows that in point of structure they cannot be separated from the Norwich Crag.

The following species of shells were collected from this exposure of the Crag, by Mr. S. C. Sothern and myself:—

——	Bed 3.	Bed 1.
Litorina litorea	×	×
Natica catena?		×
Scalaria Grœnlandica	×	
Astarte borealis	×	(very abundant).
—— compressa	×	×
Cardium edule	×	×
Cyprina Islandica	(fragments)	×
Mya arenaria	×	
Mytilus edulis		×
Nucula Cobboldiæ	×	×
Tellina obliqua	×	×
—— prætenuis	×	×
—— Balthica	×	

In the talus I found a fish-bone, fragments of *Mactra*, *Trophon antiquus*, and *Purpura lapillus*. A full list of species from Wroxham, is given in the Table, p. 42. It includes the species obtained by Mr. Reeve.

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Hoveton St. John.—The brickyard east of Wroxham Station displays a fine "jamb" of laminated clay and sand, which is used for the manufacture of red bricks.

The section at the northern end of the pit showed the following beds:—

		Feet.
Upper Crag	Warp	4 to 5
	False-bedded sand with seams of gravel, and irregular seams and streaks of laminated clay, fragments of carbonaceous matter, ironstone nodules	8 to 9
	Very micaceous, greenish-grey, laminated clay and sand, having a wavy appearance; in one place let down probably by dissolution of Chalk beneath	18
	Red sand and gravel.	

At the southern end of the pit the beds were overlaid by 3 or 4 feet of brown Clay and Gravel, representing probably the Contorted Drift.

I have been unable to trace the laminated clay further east, and it tapers away westwards through Belaugh parish. An opening to the west of the station showed:—

		Feet.
Upper Crag	Warp	1½
	False-bedded sands and sandstone	6
	Laminated clay, undulating and inclined towards the east	1½
	Sands.	

The railway-cutting north of Wroxham Station is based on a bed of laminated clay seen in places by the side of the rails. In the cutting are shown:—

		Feet.
Upper Crag	Warp Traces of Contorted Drift?	2 to 3
	Buff sands and fine subangular and pebbly gravel	6
	Gravelly bed with clay-pebbles, resting irregularly on buff false-bedded sand	1 3 or 4

East of Hoveton Green 8 feet of white and buff sand was shown. On St. Peter's Common the gravel has been worked, and in one place N.W. of the S. (on the map) of St. Peter's (Hoveton St. John), the pit showed 15 feet of gravel and false-bedded sand resting on clay.

A pit west of Hoveton House showed 7 feet of pebbly gravel and sand.

Neatishead.—A pit S.E. of Neatishead Street showed the following beds:—

		Feet.
Lower Glacial	Stony loam	3
Upper Crag	Pebbly gravel (with quartz, flint, and quartzite)	1
	White and brown sand with pebbly seams	5

A large pit east of Lodge Common Planting Pit, showed Buff Sands (Glacial) resting on pebbly gravel and sand, which belonged to the Crag series.

At Cony Hill Farm a section showed 10 feet of buff sand and laminated clays, interbedded.

Barton.—North of Neatishead Street the junction of Brickearth (Lower Glacial) and pebbly gravel may be seen. North of Barton Green the following beds were exposed:—

		Feet.
12 feet	Red gravel and sand (contorted). Brown and grey sand. Laminated clay Coarse sand and fine gravel.	2

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Horning.—At St. Benedict's Abbey the ground is gravelly, and a small excavation showed pebbly gravel (composed of flint, quartz, and quartzite) resting on reddish-brown sand.

Ludham, Potter Heigham.—Beds belonging to the Crag Series are shown in the low hills bordering the River Ant. Sections may be seen by the cottage close to the river west of How Hill; again, along Blind Lane, a pit showed 15 feet of gravel and false-bedded sand, with seams of laminated clay. South of Ludham Hall, sand pits have been opened in the Crag, but to the north and east the beds are not so clear. The ground by Cold Harbour is loamy; but here, as further east, it is only a thin soil over sand and gravel. This loamy soil becomes in places so like the Contorted Drift, that it is by no means easy to determine whether to map the ground as Crag or Drift.

Catfield, Hickling, Sutton.—Some sections of pebbly gravel were opened up along the railway, but no fossiliferous beds were exposed. The beds here were mapped by Mr. C. Reid.

Further north, in Honing parish (quarter sheet 68 S.E.), I found a fossiliferous bed, containing *Tellina Balthica*, &c., in the pebbly gravel shown in one of the railway cuttings.

Salhouse.—The occurrence of Crag in this parish was noted in 1840 by Mr. R. C. Pitt.* I have obtained no fossils in any of the sections opened, during the progress of the Geological Survey.

South-west of Salhouse Broad the following beds were shown :—

		Feet.
Upper Crag	Pebbly gravel with large pebbles of quartz and flint	4
	False-bedded sand and fine gravel	8
	Laminated clay	$4\frac{1}{2}$
	False-bedded sand	
	Laminated clay	
	False-bedded sand	

Woodbastwick.—A large pit west of the Hall showed a varied assemblage of beds, comprising laminated clay, coarse gravel, shingle, and sand (with ironstone seams), much false-bedded. I have grouped them with the Crag because all the available evidence pointed to their being of that age; in structure, however, they present some resemblances to the coarse Glacial gravel.

South of the Brickfield W. of Woodbastwick, a pit showed sand and fine gravel with seams of laminated clay (*see* p. 9).

Ranworth.—North of the *B* of Walsham Broad (on the map), there was shown in a small pit, 5 or 6 feet of pebbly gravel composed of flint, quartz, and quartzite.

Panxworth.—South-west of Peaty Mill Dam (Pedham) a pit showed 10 feet of false-bedded white and brown sand and gravel, with included masses of brown clay, with much ironstone, and flaggy beds of sandstone.

Old sand-pits may be seen by Cottenham Farm, one of which showed brown and yellow false-bedded sand with ironstone nodules and gravelly seams.

Hamlington.—The lenticular nature of the clays included in the Upper Crag was well shown in a pit near Hamlington, situated to the north-east of the church.

The section was as follows :—

15 feet -	3. False-bedded sand and fine gravel, with beds of laminated clay.
	2. Two seams of laminated micaceous clay, each about 1 foot in thickness, separated by sand in the middle of the pit; merging into one bed of clay at both ends of the pit.
	1. False-bedded sand with veins of iron-sand and casts of shells.

* Proc. Scientific Soc., London, vol. ii., p. 3.

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South Walsham.—At the eastern end of Walsham Broad, a pit showed 6 feet of buff and brown sand and pebble gravel. West of the road leading from South Walsham to Ranworth, and just inside Walsham Plantation, a section exposed 8 feet of buff and brown sand; on the opposite side of the road in Ling's Cover, there was to be seen laminated brown and white sand, having an inclination of false-bedding amounting to 40°.

South-west of Ling's Cover, a pit showed the following beds:—

	Feet.
Laminated clay and sand - - - - -	7 to 8
Brown and buff sand - - - - - -	2

A large flint occurred at the junction of the two beds.

South of the Churches a brickyard showed, in 1878, 10 feet of laminated clay. This, from not having been worked for some time, was overgrown with moss. It was pronounced by my colleagues Messrs. Whitaker and Blake to be "good Chillesford Clay." I should simply say it is a good exhibition of one of the laminated clays so characteristic of the Upper Crag.

The following notes are by Mr. Blake:—

Acle.—A small sand pit is situated about seven-eighths of a mile S. of Acle Church, adjoining the marshes at the N.E. corner of what is marked on the Ordnance map as Acle Wood; there is now, however, but a remnant of the wood existing, the timber having been felled, with the exception of a few small trees surrounding the pit. About 4 feet in thickness of red sand, blackish in places, and more or less indurated, was exposed underlying 2 or 3 feet of brown loam.

There is no gravel apparently in the immediate neighbourhood of Acle; the roads, I was informed, are mostly metalled with gravel obtained from Strumpshaw.

Halvergate.—Some gravel, more or less in the condition of shingle, has been excavated on the slope of the hill adjoining the marshy ground, three-eighths of a mile N.W. by W. of Halvergate Church.

Tunstall.—A sand pit is situated three-eighths of a mile N. by W. of Tunstall Church, on the east side of the road, close to Tunstall Lower Farm. When inspected by me, about 6 feet in thickness of well stratified brown sand, slightly pebbly in places, was exposed underlying from 4 to 5 feet of very stony reddish brown loam, mottled with a little grey. I was informed that the sand had been exacavated to a depth of from 12 to 14 feet, and that the lowest portion of it was of a whitish colour.

J. H. Blake.

II.—Wensum Valley.

Attlebridge.—A pit S. of Spring Farm showed a section of Chalk, much disturbed, capped by Boulder Clay. In the latter were relics of pebbly gravel, and at its junction with the Chalk patches of this and of the stone bed, with fragments of shells, remained *in situ.*

Drayton.—In the large Chalk-pit about half a mile E. of Drayton the Chalk is capped by an irregular deposit of pebbly gravel and sand. Above the letter *o* in the words Drayton Hall (on the map) the Chalk is covered with patches of pebbly gravel and loam; but no distinctive bed of Glacial brickearth could be mapped.

A little to the N.W. of the church, a pit showed 6 feet of pebbly gravel and sand.

Hellesdon.—About half a mile N.W. of Shepherd's Cottage the following beds were exposed (*see* Fig. 6, Plate II.):—

		Feet.
Glacial Drift	8. Warp - - - - -	2
	7. Fine pebble gravel - - -	1 to 3
	6. Stony loam - - - -	1 to 2
Upper Crag	5. Yellow sand and laminated clay - -	3
	4. Yellow and white sands with irony veins -	1½
	3. Fine gravel and sand - - -	1 to 1½
	2. Rather coarse pebble gravel, and sand -	8
	1. Pebble gravel or shingle made up chiefly of flint, with a few pebbles of quartz and quartzite. Veins of ironstone - -	

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Here Glacial gravel comes in close contact with the gravels of the Crag series. The most interesting point seen, is in connexion with the laminated clay (5), which here dovetails into the sand, showing their intimate connexion and false-bedded character.

In the grounds W. of the Asylum, a pit showed brickearth, 3 feet, capped by gravelly soil, and overlying 12 feet of yellow pebbly sand belonging to the Upper Crag.

The bluff between Hellesdon Church and Toll-bar showed the following succession of beds, but they were not clearly exposed, and I was unable to obtain measurements :—

4. Stratified sand and gravel } Glacial.
3. Vein of Brickearth - }
2. Pebbly gravel and false-bedded sand (Upper Crag), 6 or 8 feet.
1. Chalk with flints.

An excavation in St. Augustine's Road, Norwich, by the city gates, showed 5 or 6 feet of loam resting in pockets on the Chalk-with-flints.

East of Shepherd's Cottage a brick-pit showed the following section :—

		Feet.
Glacial Drift	Subangular gravel	2
	Stony loam	5
Upper Crag	False-bedded sand	5
	Pebbly gravel	3
	Blue and brown laminated clay	1
	Pebbly gravel	6

Costessey.—The divisional line between the pebbly gravel and Glacial sands is nowhere marked, owing to the absence (or obscurity) of the usual intervening bed of Glacial brickearth. (*See* p. 118.)

Earlham.—At the Grove Pit, Dereham Road, W. of Stone Hills Farm, resting upon the Chalk, the Upper Crag beds comprise 12 feet of pale false-bedded sand and pebbly gravel.

Heigham.—North-east of the Norwich Union Workhouse, Stone Hills, a pit showed 8 feet of fine gravel, resting on 9 feet of buff sand.

East of the Workhouse a pit showed the Chalk capped by 20 feet of sand and pebble gravel. Brickearth (laminated clay) was formerly dug between it and the Cemetery grounds, and was exposed in graves near the northern Lodge gate.

Sand was opened up for foundations of houses in the new crescent between the Unthanks Road and Park Lane. East of the Avenue Road a pit showed :—

Grey, sandy, and pebbly soil.
Upper Crag — Laminated micaceous sand, loams, and clay, with much iron-ore, 3 feet.
Upper Crag — Sand and flint pebble gravel, 4 feet.
Chalk.

On both sides of York Street, W. of Holy Trinity Church, more than 18 feet of sand and gravel was opened up, beneath these were traces of brickearth.

Catton.—At the Catton Lime-kiln, about a quarter of a mile W. of Wren Park, a pit showed 20 feet of pebbly gravel, composed chiefly of flint pebbles and subangular flints, with a few quartz pebbles and sand. The beds were evenly stratified, though exhibiting a little false-bedding. They contained seams of pale-coloured sand, and occasionally large unworn flints. Casts of shells were noticed by Mr. Whitaker in ironstone seams.

South of Catton Hall a large pit worked for Chalk and Gravel, known as Attoe's pit, showed 15 feet or more of pebbly gravel evenly stratified and with yellowish sandy beds at the top. My colleague Mr. Reid noticed pockets and veins of peaty-looking matter isolated in the Chalk, and commingled with the flints at the base of the pebble gravel, which reminded him of peaty beds in a similar position at Weybourn.*

* *See* Geol. Mag., Dec. II., vol. iv., p. 305.

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Sprowston.—Near Magdalen Chapel a pit showed 15 to 20 feet of the Crag series resting on Chalk. The greater part of one side of the section was made up of false-bedded gravel and sand, this became chiefly buff sand at a short distance; it was underlaid by gravel and bands of laminated clay, with ironstone nodules.

The pebbly gravel and false-bedded buff and white sands (Crag) were exposed to a depth of 12 feet beneath the brickearth (Contorted Drift) in the brickyard 1½ miles from the city gates on the Crostwick Road. (*See* p. 98.)

III.—Yare Valley.

Bauburgh.—About half a mile E. of Bauburgh Hall a pit exposed 25 feet of false-bedded sand and gravel, resting upon the Chalk.

Bowthorpe.—Pits expose false-bedded sand and pebbly gravel, with brown clayey seams, resting on an irregular surface of the Chalk.

Colney.—A pit by the bend of the lane between Colney Rectory and Little Melton, showed the following section :—

		Feet.
	Contorted loamy surface soil - - -	3 to 4
Upper Crag.	Pebbly and subangular gravel - - -	6

A pit by the kiln W. of Colney showed a thin capping of pebbly sand resting in pockets on the Chalk.

At the N.W. corner of Beck Pease plantation a large pit showed the pebbly gravel resting on the Chalk, and capped by buff sand with chalk grains (Glacial).

Earlham.—South of Bunker's Hill a pit showed 6 feet of laminated pebbly sands very ferruginous in places, and containing pebbles of flint, sandstone, angular pieces of flint, and small pebbles of Chalk. These beds rest on an undulating surface of the Chalk, and their classification with the Upper Crag is doubtful.

Eaton.—The pebbly gravel is well shown in pits W. of the Hall, and by the Car.

One of the best sections is at the nursery grounds of Mr. Ewing, where 15 feet of pebbly sands and gravel, with occasional seams of laminated clay, may be seen resting on the Chalk. In reference to this section Lyell made the following remarks :—"As to the age of the gravel and sand overlying the Chalk at Eaton, there can be no doubt that it belongs to the Norwich Crag, as there are not only casts of marine testacea characteristic of that formation in the ferruginous sandstone ["Iron-pan"] at Eaton,* but also, as I learn from Mr. J. B. Wigham, some shells of the genera *Mya*, *Mactra*, *Cardium*, and *Mytilus*, in which the calcareous matter is still preserved." †

It is probable that a "jamb" of clay at one time existed in the Crag of this immediate neighbourhood, as in 1868 Mr. J. W. Ewing drew attention to a pottery kiln, belonging to the time of Queen Anne, which had beeen opened up in his grounds.‡

Another pit by the Old Heath, towards Hartford Bridge, showed 15 feet of pebbly gravel and sand with seams of laminated clay.

And at Hartford Bridge a "jamb" of clay occurs in considerable thickness. The following is the section (*see* Fig. 7, Plate III.) :—

		Feet.
Upper Crag	4. Pebbly gravel - - - -	10
	3. Wedge of pebbly gravel (three feet) -	
	2. Laminated clay, with nests and veins of sand and fine gravel dovetailing into the pebbly gravel - - - -	5
	1. Sand and shingle- - - -	4 to 6
A. Chalk.		

* Noticed also by J. E. Taylor, Norf. News, Sept. 9, 1871.
† Phil. Mag., 1839, p. 260.
‡ Norfolk News, July 11, 1868.

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The mode of occurrence of the clay and sand proves the intimate connexion of the deposits, for not only does the clay contain lenticular patches of pebbly sand, but itself forms a great mass, false-bedded with the overlying sand and gravels. No such a mass of clay is seen in the adjoining pit at Eaton where Crag shells have been found. This wedge-shaped mass is about 20 feet in length.

In Bed 1 I obtained a bone which my colleague, Mr. E. T. Newton, tells me is either that of an Elephant or Whale. A shark's tooth partially imbedded in phosphatic matter, in the possession of the landlord of the "King of Prussia," had been (I was informed) found in this same bed.

Eastward the beds were disturbed and let down 5 or 6 feet in a pot-hole or pipe in the Chalk.

Cringleford.—South of Oakland House (the residence of Mr. F. W. Harmer, F.G.S.), a pit showed pebbly gravel with occasional seams of laminated clay resting on the Chalk.

North of Cringleford Hall, 12 feet of fine pebbly gravel and sand were shown.

Intwood.—At the marl pit N.W. of Intwood Church, between the Boulder Clay and the Chalk, are traces of the pebbly beds.

South of the Foxburrow Plantation are pits in gravel containing flint, quartz, and quartzite.

The gravel is very pebbly and much disturbed, so that the bedding is mostly obliterated. 15 feet of gravel was shown resting on the Chalk.

Keswick.—S.W. of Keswick Hall a pit showed 9 feet of pebbly gravel and sand, with large flint boulders, much quartz and quartzite. The sand is contorted in places. (*See* p. 104.)

Lakenham.—About 15 feet of pebbly gravel was shown in the cuttings of the Trowse loop line, N. of Lakenham Church.

By the *M* of Mills (on the map), 6 feet of false-bedded brown and yellow sand was shown.

One fossil, *Pecten opercularis*, has been recorded from the Crag in this parish.*

S. Woodward also mentions (in a MS. record) that Crag shells were found immediately above the Chalk in sinking a well on the west side of the Bracondale Road, about 300 yards from Ber Street Gates. The superincumbent beds were white sand, brickearth, and gravel, altogether 60 feet in thickness.

It is also important to mention that in reference to the shells noticed by J. W. Robberds† as having been found by Dr. Yelloly in his grounds at Carrow Abbey, S. Woodward states that they were shown to him by the Doctor and were "the edible welks (the *Murex striatus* [*Trophon antiquus*], and *Buccinum undatum* of Linnæus) the refuse of the Nuns' table."‡

Behind Bracondale Cottage, as I am informed by Mr. S. W. Utting, there is a bed of clay 2 or 3 feet in thickness, which is no doubt a seam in the Crag series.

Tese Valley.

Long Stratton.—In a pit about a quarter of a mile from Long Stratton in the lane leading towards Tharston Church, 14 feet of pebbly gravel and sand was shown.

Tharston.—A deep gully near the end of Wood Lane, west of the Great Eastern Railway, displayed a good section of laminated micaceous clay and sand.

A good section was shown at Tharston Furze Hill (Fig. 10, Plate III.).

Above the Chalk was seen the stone-bed (1), and this was overlaid in one part by a bed of laminated clay (2), and a mass of buff and brown false-bedded sands (3), all belonging to the Laminated or Crag Series. Above these in one part of the pit was a lenticular patch of Chalky Boulder Clay (4), and this

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* S. P. Woodward, in Gunn's Geology of Norfolk.

† Eastern Valleys of Norfolk, p. 10.

‡ Letter to J. W. Robberds, 17 Oct. 1826.

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was covered by coarse flint gravel (5) like that which covers a great part of Mousehold. The total thickness of the beds exposed was about 20 feet.

Bones have been found in the Stone-bed, and an elephant's tooth, identified by Mr. Gunn as *E. leptodon*,* was found in the gravel about 3 or 4 feet above the Chalk. The spot roughly indicated to me by a workman was, from 3 to 4 feet above the Chalk, where the coarse gravel and Crag gravel came together, and as the section had been cut back since, it was not possible to decide from which formation it had been obtained.

The sand has been used for making mortar.

Forncett St. Mary.—At Bays' Farm a pit showed 15 feet of pebbly gravel and sand with fragments of shells, and cuttings in the new loop line of railway show that this crops out in the slope above Low End. Boulder Clay, however, skirts the lower ground.

Stratton St. Michael.—The sand-pit by the cross-roads south of Stratton Bridge, showed 7 feet of red sand and pebble gravel, capped by 5 feet of clayey gravel, probably Glacial Drift. About 20 feet of pebbly gravel and sand was shown in pits between this and the Alder Car.

Pits east of Boyland Hall showed buff sand, 6 feet in thickness.

S.W. of Long Acre plantation sand and gravel was to be seen in the bank bordering the Alluvium.

Tasburgh.—A pit by the White Horse Inn showed :—

		Feet.
Upper Crag	Yellow sand and gravel	6
	Laminated clay and brown sand	4 to 5
	White sand and shingle	4 to 5

Chalk.

A pit at Tasburgh Hill showed the following beds (*see also* p. 127) :—

	Feet.
3. Sandy soil with large flints and traces of Boulder Clay	6 to 8
2. Pebbly sand and gravel (Upper Crag) about	30
1. Chalk.	

South-east of the Church an old pit showed a cliff of gravel, coarse in places near the upper part, and from which it is difficult to separate the Crag Series.

Hapton.—A pit about ¼ mile W. of Hapton Church showed laminated clay with carbonaceous specks, resting on quartzose sand and gravel, together 6 feet in thickness. (*See* p. 131.)

Flordon.—In the valley opposite Hapton Hole a large gravel pit exposed the following beds :—

Glacial Drift. Stony loam with patches of marl.

		Feet.
Upper Crag	False-bedded red sand and gravel, with few flint and many quartz pebbles	5 or 6
	Red, brown, and white sand and shingle, almost entirely made up of flint pebbles	10

Traces of pudding-stone were to be seen in the lane cutting between Flordon Station and Tasburgh Ford, where the pebbly gravel had been cemented.

West of the Railway Station a pit showed 8 feet of false-bedded sand and pebble gravel.

Saxlingham Nethergate.—West of Low Farm a pit was opened to the depth of 6 feet in disturbed white and buff sand and clayey gravel.

A pit south-west of the Church showed 10 feet of yellow and orange-coloured false-bedded sand with lines of fine gravel.

Pits on either side of the lane east of the Baptist Meeting House, and north of Fox Hole showed :—

		Feet.
Upper Crag	Buff false-bedded sand and fine gravel, with bands of clay and ironstone nodules	10
	Pebbly gravel with flint, quartz, and quartzite pebbles, and a few large flint-boulders	6 to 7

* Proc. Norwich Geol. Soc., vol. i., p. 35. *See* remarks on this species by E. T. Newton, Geol. Mag., Dec. II., vol. viii., p. 316.

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On Sendalls Marsh pebbly gravel and laminated clay occurred.

The occurrence of the Crag in this parish was, I believe, first noticed by the late Rev. S. W. King, rector.* Shells were observed in the pit on Smockmill Common, but the only fossiliferous bed I could discover when examining the locality in 1876, in company with my friend Mr. S. C. Sothern, was a bed composed of comminuted shells.

One species recorded is *Leda lanceolata* (fragments),† and Mr. J. E. Taylor mentioned his finding *Turritella terebra* (*communis*) at Saxlingham, where Mr. Wood recognized the Chillesford beds as present "in a feeble form resting on the Chalk."‡

Remains of Mastodon have also been recorded from a pit in the parish of Saxlingham Nethergate.§

Newton Flotman.—Here 8 feet of very pebbly gravel and sand rests on the Chalk, which is worked at this locality. Shells have been found in the Crag here. A bed of rolled flints, 1 to 2 feet in thickness, occurs at the base. The Chalk is opened to a depth of 9 feet.

South-west of Newton Hall I noted the following section in company with Mr. S. C. Sothern (1879):—

		Feet.
Upper Crag	Pebbly gravel	12 to 15
	Streak of clay	
	Stone bed, iron-stone nodules, fragments of shells among which *Purpura* was present	1
Chalk		12

At the brickyard S. of Swainsthorpe, the Glacial beds rest on buff and white false-bedded sand (see p. 113).

Shottesham.—Pebbly gravel is shown in pits on the borders of the valley between the Lodge and Sheets Hill.

In 1664 was published a curious work by Thomas Lawrence, entitled "Mercurius Centralis; or a Discourse of Subterraneal Cockle, Muscle, and "Oyster-shels, found in the digging a well at Sir William Doylie's, in "Norfolk." The property of Sir W. Doylie (or D'Oyly) held at this date was the Shottesham estate. All the information given about the well was that it "was digged so many feet deep." Shottesham Old Hall is situated on the Chalky Boulder Clay from which these fossils might have been obtained, but they were more probably found in the Crag series, into which the well was most likely carried.

Stoke Holy Cross.‖—A pit situated about half way between the Church and the Mill showed the following beds:—

		Feet.
Glacial Drift	Brown false-bedded sand and fine gravel	7
	Fine laminated clayey sand	3
	White and pale-brown false-bedded sand with fine gravelly seams and chalky grains	12
Upper Crag	Gravel and shingle	8
	Sand	2
	Laminated clay and sand	1 to 1½
	Shelly seam and stone bed, with bones of *Bos* and *Cervus, Trophon antiquus, Mytilus edulis*	1
Chalk with flints (16 feet shown).		

The shells I obtained myself; the bones I purchased from a workman, who pointed out the position (at the base of the Crag) where he obtained them. (*See also* p. 167.)

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* Noticed also by S. V. Wood, jun., Quart. Journ. Geol. Soc., vol. xxii., p. 551.
† S. P. Woodward, in Gunn's Geology of Norfolk.
‡ Geol. Mag., vol. iv., pp. 282, 376.
§ White's History and Directory of Norfolk.
‖ Shells were found here by J. E. Taylor, Geol. Mag., iv., 282, 376.

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Dunston.—S.E. of the church a pit showed 10 feet of subangular flint-gravel, and sand.

East of Brick-kiln Cottage the railway cutting shows:—

Pebbly gravel.
Chalky Boulder Clay, with base of stony loam.
Laminated clay, sand, and pebble gravel much disturbed (Crag Series).
Chalk.

Markshall.—The great cutting through Chapel Hill is chiefly gravel and sand with traces of Boulder Clay; the lower portions of the section exhibit seams of laminated clay, and represent the Crag Series. At the base is a stiff brown clay.

East of the word "Tumuli" (on the map) a pit showed 8 feet of pebbly gravel, with a few large flints.

Arminghall.—About half a mile S.E. of Lakenham Bridge the following section may be seen:—

		Feet.
Upper Crag	Sand and pebbly gravel	10
	Shell-bed	3 to 4
	Laminated clay	2
Chalk.		

The section at Arminghall is of interest in showing a bed of shells above a band of clay, which has been termed the "Chillesford Clay," and which rests upon the Chalk.

Attention was drawn to it in 1869 by Mr. J. E. Taylor, who pointed out that the clay rested directly upon the Chalk, excepting the usual stone-bed, and was capped by a bed containing Norwich Crag shells. A species of *Mactra* was so abundant that the bed (he said) might be called the "*Mactra solida* Crag," as the bed at Weybourn was the "*Tellina Balthica* Crag."

The following is a list of the species obtained by myself:—

Litorina litorea, *Linn.*	Mactra ovalis, *J. Sby.*
Natica, sp.	Mya arenaria, *Linn.*
Purpura lapillus, *Linn.*	Mytilus edulis, *Linn.*
Cardium edule, *Linn.*	Tellina obliqua, *J. Sby.*
Cyprina Islandica, *Linn.*	——— prætenuis, *Leathes.*

Vertebra of fish.

Thorpe Hamlet, Norwich.—At St. James' pit an excellent section of the Crag beds is shown:—

		Feet.
Upper Crag	False-bedded white, yellow, red, and grey sand and fine gravel, with impersistent mass of laminated clay near the middle, at the eastern end of the pit	25
	Laminated clay and sand	3
	Gravel and large worn flints, resting on irregular surface of Chalk, with nests of iron-sand and comminuted shells. *Mytilus edulis, Astarte borealis*	2
Chalk.		

Traced towards Catton the beds pass into shingle as seen at Attoes Pit (p. 67).

In a MS. record S. Woodward states that "Mr. R. C. Taylor informed me "some years since that in sinking the well at the back of the houses on the "brow of this hill (Kett's Castle Hill) a bed of shells was perforated." (*See* p. 165).

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* Norwich Geol. Soc., Norwich Mercury, Nov. 18, and Norfolk News, Nov. 18, 1869.

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A section exposed at the gasworks, during the construction of a new gasometer in 1877, showed :—

		Feet.
Glacial stony loam, a trace.		
Upper Crag	Light-coloured pebbly sand	12
	Clay	3 to 6
	Yellow sand	3 to 6
	Laminated clay	1
	Yellow and brown sand, with vein of coarse gravel	12
Chalk.		

In the large pit south of Bishop's Bridge, called Lollard's Pit, the Upper Crag is well exposed beneath the Glacial brickearth, and shells have been found at the base of it. I also obtained a piece of granite from the Crag. Here it is marked near the middle by three thin impersistent bands of laminated clay which Professor Prestwich classed (though somewhat doubtfully) with the "Chillesford Clay." They serve, however, to connect as one conformable series, beds which have been otherwise divided into Norwich Crag, Chillesford Clay, and Lower Glacial Sands, and which have been considered to be unconformable (*see* Fig. 3, Plate II., and p. 5).

The sections taken at different times in this district show great variations.

Thus S. Woodward (1825) gave the section of the beds between the Chalk and Brickearth as follows :—

	Feet.
Quartzose sand	10
Red and yellow sand	10
Gravel	12
	32

Mr. S. V. Wood, junior (1865), made the following divisions* :—

	Feet.
Light sands	20
Alternating sands and loams	6
Red sands	7
Light sands	5
Coarse gravelly loam	3 to 4
	42

Professor Prestwich thus divided the beds in a paper read in 1870† :—

	Feet.
White sands and flint-shingle (which he called "Westleton beds")	20
An irregular seam of grey clay ("Chillesford Clay"?)	0 to 1
White and ochreous sands, and flint-shingle and gravel. Small patches of shells (Norwich Crag) found occasionally in the lower part, and large flints at the base	12
	32

Chalk.

Thorpe.—Thorpe is one of the best-known localities of the Norwich Crag. Three pits have been opened at the eastern extremity of the village; the one at the kiln immediately west of the Cromer branch railway (where it crosses the Norwich and Yarmouth road) is the only pit where shells are now obtained. This henceforth will be spoken of as the Thorpe pit. Another pit was in former years worked a little further east (near the Toll-gate), on the other

* Remarks in explanation of his map (1865). At this time Mr. Wood grouped all the beds above the Chalk up to and including the Brickearth on top of the beds here given, as Middle Drift.

† Quart. Journ. Geol. Soc., vol. xxvii., p. 469.

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side of the railway, and a third was worked to the west of the kiln; both are now deserted and overgrown with vegetation.

The pit near the Toll-gate was the one described in 1835 by Mr. R. Fitch, and here he obtained a specimen of Mastodon. In the year previous, S. Woodward mentions that "in company with Joseph Prestwich, Esq., we dis-"covered a molar tooth of the Elephant in the pit by Thorpe Toll-gate, which "had been recently disinterred from the Crag, and was thickly coated with "ferruginous sand." The specimen, which was picked up by Mr. Prestwich, was afterwards determined to be *E. meridionalis*, and placed in the Norwich Museum.

One of the Thorpe pits was also described by S. Woodward (MS.) in 1825: "We here see a bed [of shells] 10 feet thick, tapering off to a point towards "the valley, proving that these shells are deposited in isolated patches or "shoals."

"The Chalk here as usual is covered with flints imbedded in clay, then a "bed of shells 7 feet thick, next a layer of clay and shells about 1 foot thick, "then about 2 feet of shingle, and above this 12 feet of brickearth and "vegetable mould."

The general section of the Crag beds at Thorpe Kiln will be seen from the accompanying section: a full list of fossils is given in the Table, p. 41, from specimens recorded by Mr. S. V. Wood, Prof. Prestwich, Mr. R. Fitch, Dr. S. P. Woodward, Mr. J. Reeve, myself, and others.

The following is the section, which I noted in 1875, *see* Fig. 1, Plate III.:—

	Feet.
5. Irregular sandy capping, thickening out to - -	4
4. False-bedded sand and shingle, formed chiefly of flint and quartz, hardened in places and at various levels into a black ironstone-conglomerate or "iron-pan," which contains casts of shells - - - - -	8 to 12
3. False-bedded sand and pebbly gravel with irregular seams of micaceous sandy clay; shells at base - -	2 to 4
2. White and buff false-bedded sand with shell-patches -	5
1. Rolled flints and clay, with sand, pebbles, and shells. "Stone Bed" - - - - - - -	1 to 1½
A. Chalk with flints and paramoudras, 20 feet shown.	

The strata are very clearly shown, but not the sub-divisions that have been made. There is a conspicuous shell-bed, sometimes 6 feet in thickness, occupying patches in the white and buff-coloured sand (2) stretching along the face of the quarry, and there are thin beds of brown rudely stratified and impersistent clay above it (3)—termed by some the Chillesford Clay. Shells are found at all horizons between the Chalk and this clay, but they are very local, for in places the beds are entirely unfossiliferous from top to bottom. Nowhere are there two marked or persistent horizons of Crag beneath this clay.

Mr. Prestwich, who identified a grey clay about the horizon of Bed 3 with the Chillesford Clay, admitted that the line of separation between the Chillesford beds and Fluvio-marine Crag was "not well marked."* I do not think it is shown at all. Mr. S. V. Wood, jr., in his latest communication on the subject, states that all of the Crag at Thorpe "is fluvio-marine, the division "into a fluvio-marine bed below and a marine one above (which exists at "Bramerton) not obtaining here." † At the base of Bed 4 Mr. Prestwich obtained a fragment of Deer's horn.

Mr. Fitch (in his paper before alluded to) noticed the occurrence of shells, principally Pectens, in the stone bed.

During the last three or four years the beds have been worked back to a considerable extent, and I have seen a large surface of the Chalk exposed by the removal of the "uncallow."

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* Quart. Journ. Geol. Soc., vol. xxvii., p. 456.
† *Ibid.*, vol. xxxvi., p. 461.

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The stone-bed, about 2 feet in thickness, contains great boulders of flint in a loamy matrix, and yields *Pecten opercularis*, *P. pusio* (one specimen), *Tellina obliqua* (pairs), *Tellina crassa*,* *Mytilus edulis* (pair), *Mya* (pair), *Mactra*, *Buccinum tenerum*, *Trophon antiquus* (large specimens), &c.

The bones occur most abundantly *on* the surface of the stone-bed, not in it nor under it. I obtained a portion of a tusk in September 1878, and saw, the day after, the exact position in which another portion of tusk, 4 feet 6 inches in length, had been obtained. This was on the surface of the stone bed. (*See* p. 39).

As Mr. Whitaker pointed out to me the Chalk is somewhat hardened in places, immediately below the Crag. He picked out one or two small "coprolites."

Casts of shells, "about 10 or 12 feet higher than the bed of rejectamenta," were noticed so long ago as 1837 by the Rev. Thomas Clowes.† They were subsequently noticed by Lyell,‡ R. C. Pitt,§ Prestwich,‖ and J. E. Taylor.¶ They occurred in the "iron-pan," and I obtained the following species at the eastern end of the pit:—

Litorina litorea.	Mytilus edulis.
Purpura lapillus.	Nucula Cobboldiæ.
Cardium edule.	Tellina Balthica?
Modiola (large sp.).	——— obliqua.
Mya arenaria.	

In the railway cutting (on the Cromer branch line), north-east of the lime-kiln, the pebbly beds were shown to be much disturbed (*see* p. 118).

Excavations by the new Asylum buildings showed gravel and sand interchanging abruptly.

On the Yarmouth railway the cuttings showed the beds to be much disturbed, where overlaid by the Chalky Boulder Clay.

At the new parsonage house, Thorpe, I was informed by Mr. E. Gidney that shells were obtained in the Crag in sinking the well.

An old pit now forming part of Mr. Howard Taylor's garden, showed about 10 feet of pebbly gravel with clayey seams and ironstone nodules resting on the Chalk.

The following section at Thorpe was recorded by Trimmer; he noticed "no Crag shells":**—

		Feet.
[Glacial.]	Loam, with patches of gravel - - -	30
[Upper Crag?]	Sand, with seams of gravel - - -	21
	Clay, sand, and gravel - - - -	19
Chalk.		

S. Woodward (MS., 1825) says, "The pit in the village of Thorpe presents "a section of about 100 feet, 40 of which is in the chalk stratum, the remainder "diluvial beds of sand, gravel, and clay. Just above the chalk is a thin layer of "greyish blue clay, but no trace of the nodular flints reposing on the chalk, as "in those sections where Crag shells occur."

Little Plumstead.—Sections, about 12 feet in thickness, of false-bedded sand and gravel, with laminated clay-seams, are seen N.W. of the Hall by the Church, and in the valley between the Church and the Rookery Farm.

I was informed that at the brickkiln at Plumstead Street, sand, loam, shells, &c. were met with below the brickearth (glacial) at a depth of 13 feet from its surface. (*See* p. 99.)

Postwick.—The section at Postwick Grove is now so much obscured by talus that the structure of the beds cannot be seen, and the shells are only to be

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* First noticed here by Mr. W. M. Crowfoot.
† Letter to S. Woodward, dated South Town, Yarmouth, Mar. 27, 1837.
‡ Phil. Mag. 1839, p. 261.
§ Proc. Scient. Soc., vol. ii., p. 4.
‖ Geol. Mag., vol. vii., p. 539; Quart. Journ. Geol. Soc., vol. xxvii., p. 469.
¶ J. E. Taylor, Norf. News, Sept. 9, 1871.
** Quart. Journ. Geol. Soc., vol. i., p. 308.

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collected from the rabbit-burrows, There appears to be about 20 feet of rather angular and pebbly gravel and sand, resting upon the Chalk.

A section noted by S. Woodward (MS. 1825) showed the following beds:—

	Feet.
Ferruginous sand and vegetable mould, about	6
Bed of shells, terminating towards the north—10 yards in length, about	4
Flints mixed with gravel and clay.	
Chalk.	

Two shell-beds, as I was informed by Mr. Fitch, have been noted at Postwick.

Mr. J. E. Taylor* observed that at Postwick Grove the lower bed may also be seen reposing on the Chalk, and here the upper bed consists of irregular patches or "nests" containing hardly anything else but *Cyprina Islandica* in great quantities, sometimes in pairs. *Rhynchonella psittacea* was found in the Upper bed.

Crag shells were formerly to be obtained in two or three spots in Postwick, but the pits are overgrown and the sections obscured.

By the *P* of Parsonage Farm (on the map) the following beds were shown, and I obtained the following species in company with Mr. Gunn :—

Upper Crag	Pebbly gravel and sand, with many specimens of *Purpura lapillus*, also *Litorina litorea*, *Turritella incrassata*, *Pleurotoma*, *Cardium edule*, and fragments of *Mya*, *Pecten*, *Tellina*, &c.	
	Micaceous clay	3 ins.
	Stone bed and sand.	
Chalk.		

Shells have also been found in the rectory garden by the Rev. W. Vincent.†

The cuttings on the railway north of Postwick Grove, and east of Postwick, showed the Crag in several places overlaid by Chalky Boulder Clay, which rested most irregularly upon it. In several places the Crag was very much disturbed.‡ In one place a laminated clay occurs, with shells above and below it. I found *Litorina litorea*, *Purpura lapillus*, *Cardium edule*, and *Mya arenaria*. (*See* p. 118.)

In the pit near Postwick Church, the surface of the Chalk was drilled by Annelides and contained *Pholas crispata*.§

Tellina Balthica (*solidula*) has been reported from the "top bed" at Postwick by S. P. Woodward, but this appears to have arisen from the word Postwick being misprinted for Crostwick.‖ (*See* p. 33.)

A full list of shells from Postwick is given in the table, p. 41, on the authority of S. V. Wood, S. P. Woodward, and from the specimens collected by myself.

Witton.—Sections of fine pebbly gravel (5 feet) were opened up by the *i* of Witton (on the map), and of buff sand (10 feet) by the stream to the north-east.

Blofield.—In the valley south of Blofield corner, and N.W. of the *P* of Plumstead Hall (on the map), 10 feet of buff sand was opened up.

Brundall.—The escarpment above the railway extending westward from the station, is capped by buff false-bedded sands, shown in pits to a depth of 8 feet, below which occurs, with some local persistence, a bed of laminated clay shown in the bank at the railway-station. This throws out slight springs.

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* Norwich Geol. Soc., 1866.

† *See* Excursion of Norwich Geol. Soc., Norwich Mercury, July 18, 1871.

‡ Noticed by J. Trimmer, Quart. Journ. Geol. Soc., vol. i., p. 302. In this paper Crostwick is put for Postwick, p. 302.

§ S. Woodward, Geol. Norfolk, p. 20; Lyell, Mag. Nat. Hist., vol. iii., p. 316.

‖ *See* Harmer, Trans. Norfolk Nat. Soc., vol. ii., p. 377.

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In the wood south of Brundall Church the following beds were exposed:—

		Feet.
Upper Crag	Warp	3 to 5
	Pebbly sands	6
	Laminated clay	5
	Sands with occasional gravelly seam, and shells at intervals. Base not seen	15

In this pit univalves were scarce, even *Litorina litorea* was rare, but the Crag was especially rich in *Cyprina Islandica*, entire valves of which, although not in pairs, were very abundant. *Astarte borealis, A. compressa, Leda oblongoides, Lucina borealis*, and *Tellina obliqua* were common; while *Tellina prætenuis* and *Nucula Cobboldiæ*, the latter most abundant in the railway-cutting further east, were rare. A full list of shells from Brundall is given in the table, p. 42, and this includes notes of species collected at Brundall station by Mr. T. G. Bayfield, and Mr. Sothern, as well as those subsequently collected by myself.

The railway cutting, and a pit a little further north by the road side, showed the following beds, which were opened up in 1875:—

		Feet.
Upper Crag	Buff and brown false-bedded sand and shingle, with occasional unworn flints, and numerous seams of laminated clay	15
	Laminated clay, tapering eastwards	3
	Sand and gravel	2 to 3
	Sand with shells	1 to 1½
	Buff sand (beneath level of railway), base not seen	6

The clay was (Sept. 1878) opened up for brickmaking about a quarter of a mile east of the station, and there was a thickness of 7 or 8 feet of sandy brick-earth. The shell-bed yielded, besides other species given in the table, *Bulla* sp., *Ringicula ventricosa, Trochus tumidus, Astarte sulcata, Cardium edule, Modiola modiolus, Mya arenaria, M. truncata?, Tellina prætenuis*, and *T. lata*, and several other species, which I did not meet with in the pit near the church. Mr. Bayfield found fragments of lignite, and I obtained one pebble of quartzite in the Crag. On the other hand, *Turritella terebra* found by myself, and *Abra prismatica* found by Mr. Reeve in the pit by the church, have not been recorded from the railway-cutting. These facts are of course merely of interest in showing the local prevalence of certain species. The Brundall Station Crag might be called the "*Nucula Cobboldiæ* Crag," just as other exposures have been called "*Tellina Balthica* Crag."

Bradeston.—A pit by the farm S.E. of the church, showed 15 to 20 feet of buff and white sand with thin seams of laminated clay.

Strumpshaw.—South of Lakeford a pit showed the following beds:—

		Feet.
Glacial?	5. Gravel	3 to 4
	4. Sand	
Upper Crag	3. Lenticular mass of clay and sand	3
	2. Indurated clayey sands	
	1. Bright ochreous and pale buff sand with gravelly seams	9

Buckenham.—A section by the railway station showed 14 feet of false-bedded sand and shingle.

The following notes are by Mr. Blake:—

Hasingham.—A gravel pit is situated near the south-west corner of the field to the E. of the church. About 18 feet in thickness of very pebbly gravel, intermixed with a little brown sand, was exposed. I observed a small boulder of grit, 4 inches in diameter in the gravel, which latter mostly consisted of pebbles of flint and quartz.

Cantley.—A small sand pit is situated half a mile S.E. by E of Cantley Church, on the east side of Spong Farm. Reddish-brown stony and loamy

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sand, 5 feet in thickness, was exposed overlying a few feet of light brown sand.

Moulton.—A gravel-pit, showing an interesting section, is situated three-quarters of a mile S.W. by W. of Moulton Church. On the north-east side of the pit, the following section occurs :—

	Feet.
Soil	1
Very stony stiff brown loam [Glacial Drift]	6
Pebbly gravel and shingle, consisting of flint and quartz	1
Buff and orange-coloured stratified sands, pebbly and gravelly in places	5½
Micaceous grey loamy-clay, more or less laminated	1½
Thinly stratified grey, white and buff-coloured sand, with streaks of grey loam, micaceous, and with a few pebbles	3

On the south-west side of the same pit, where the surface of the ground is at a lower level, the section is as follows :—

	Feet.
Soil	2
Pebbly gravel and shingle	1½
Orange-coloured pebbly sand, with patches of pebbly gravel, more or less indurated	5
Shingle and pebbly gravel	2
Stratified light brown sand, containing a few pebbles	2
Laminated grey clay and orange-coloured sand, very micaceous	1½

There is a pond in the middle of the pit, the water evidently being kept up by Chillesford clay.

The sections exposed in the above pit clearly show the following succession of beds, viz., Loam, Pebbly-beds, and Chillesford-beds. And inasmuch as the Loam is overlaid on the higher ground near the wind-mill by a considerable thickness of sand, which latter a little further north is overlaid by Chalky-boulder-clay, we have the succession in this locality of the five following formations clearly demonstrated, the sequence being :—

[Glacial Drift] { Chalky-boulder-clay. / Sand. / Loam.
*Pebbly gravel and shingle.
*Chillesford-beds.

Southwood.—Two small gravel-pits occur at the crossways about a quarter of a mile N.W. of Southwood Hall. The gravel consisted mostly of flint, and was very pebbly and mixed with sand. About 8 feet in thickness was shown in one pit, the other was mostly filled in.

Limpenhoe.—A large old sand-pit is situated five-eighths of a mile S.E. by S. of the church, near Limpenhoe High-house, on the slope of the ground, which now forms a steep escarpment mostly overgrown with brushwood, &c. At the western part of the pit, about 15 to 20 feet in thickness of brown sand, occasionally false bedded, and much indurated in places, is exposed overlying very micaceous laminated grey clay and brown sand containing some ferruginous nodular concretions, evidently Chillesford beds.

A good exposure showing 9 feet in thickness of pebbly gravel occurs in a pit opposite Limpenhoe High-house, in a field on the east side of the road leading down to the marshes.

Pebbly gravel was shown in a pit—now filled in—south of the road, a little more than a quarter of a mile E.S.E. of Limpenhoe Church.

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* These beds I group together as Upper Crag, not recognizing the persistence of any particular horizon of clay, sand, or gravel. Mr. Blake's views on the classification of the Pliocene and newer beds in Norfolk, are clearly expressed in his Address to the Norwich Geol. Soc. *See* Proc., vol. i., p. 137.—H. B. W.

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Clay, Loam, and Sand occurs on the low ground in the neighbourhood of Low Farm; and is shown, on ascending the road N.E. of the Farm, to underlie gravel. The Clay, &c., of which no good section was exposed, probably belongs to the Chillesford beds, and is no doubt a continuation of the micaceous laminated grey clay and sand, underlying a considerable thickness of gravel and sand—exposed on the low ground near the marshes to the W. of Limpenhoe High-house.

Reedham.—In the railway-cuttings, forming a triangle to the E. of Reedham railway-station, about 20 to 25 feet or more in thickness of reddish and yellowish-brown and buff-coloured pebbly gravel and sand is exposed; beneath which, and commencing at about the same level as the rails, I observed, in places, micaceous white and brown sand containing ferruginous nodular concretions; indicating either the presence of the Chillesford beds themselves or else their proximity. At the angle formed by the slopes of the cutting N. of the railway-bridge over the river Yare, a little grey stratified and reddish-brown unstratified loamy-clay is exposed at the top part of the cutting, overlying the gravel for a distance of about 40 or 50 yards. It is somewhat similar to the loamy-clay overlying the pebbly sand and gravel and Chillesford clay, exposed in the brickyard to the north-west, near the railway-bridge.

Gravel and sand intermixed and of a brown colour is exposed in a pit S.E. by S. of Reedham railway-station. The gravel consists mostly of flint, pebbly and subangular, and quartz pebbles.

Several sections showing gravel and sand intermixed, are exposed in the escarpment south of Reedham Hills, extending for about a quarter of a mile in length to the W. of the railway-bridge across the river Yare. The sand is of a brown colour and is interstratified with gravel, which latter mostly consists of small pebbly and subangular flints and quartz pebbles. In one place I observed a lenticular patch of brown loam, 3 or 4 feet thick, in the middle of the gravel and sand; and in another place, some mottled grey and reddish-brown stony and loamy-clay overlying the gravel and sand.

A gravel-pit occurs on the west side of the road, one-and-three-eighths of a mile N.W. by N. of the church. The pit was mostly filled in when visited by me, but about 6 feet in thickness of brown loam was exposed on the south side of the pit, overlying about 6 feet of very pebbly reddish-brown and buff-coloured sand and gravel, the total thickness not being shown.

Gravel was exposed in digging a ditch to obtain material for forming a bank, on the west side of the road, a little more than three-quarters of a mile N. of the railway-station, and about half a mile S. of the large brickyard.

A brickyard is situated three-eighths of a mile E. of the railway-station, south of the railway and close to the bridge. In an excavation here, a fine section of Chillesford Clay, 11 feet thick, was clearly exposed, showing numerous thin bands of micaceous grey clay interstratified with brown sand, there being about an equal proportion of clay and sand, the clay perhaps in places preponderating. The lowest portion consisted of white sand, 6 inches to a foot in thickness, apparently occurring in patches in buff-coloured sand. Pebbly gravel and sand—of the same nature that occurs in the adjoining railway-cuttings and at the escarpment at Reedham Hills—overlies the Chillesford Clay at the west end of the pit, but at the east end, 3 or 4 feet of brown and buff-coloured sand, false-bedded in places, intervenes between the gravel and the Chillesford Clay. A line of denudation is clearly shown—as is so frequently the case—on the upper part of the Chillesford Clay at the western end of the pit, where the beds which undulate—another characteristic of them—are shown dipping towards the east, where they become more or less horizontal. About 5 or 6 feet in thickness of Chillesford Clay has been denuded at the western end. (*See* pp. 34, 35.)

Wickhampton.—A small gravel-pit occurs on the north-west side of Wickhampton Farm, nearly half a mile S.W. by W. of the church. The gravel, consisting mostly of flint and quartz pebbles, is of a reddish-brown colour, and 7 feet in thickness was exposed.

Another pit of larger size is situated on the east side of the Farm, but was mostly filled in and otherwise covered by talus, when seen by me. I was informed that loam overlaid the gravel in the highest part of the pit, and observed a large boulder against one of the Farm buildings, evidently taken out of the loam in the immediate vicinity.

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A sand-pit occurs in a field to the west of the Farm situated one mile and a quarter E. of Freethorpe Church, and close to Wickhampton Church, on the north side of it. About 9 feet in thickness of reddish-brown sand was here overlaid by some gravel.

J. H. Blake.

Trowse.—In the Chalk-pit, near Crown Point, a good section of the Crag series with two fossiliferous seams was shown. One seam was about 9 feet above the Chalk, and like the bed at Arminghall, above a bed of laminated clay, called "Chillesford Clay;" while the other occurred in patches directly on the Chalk, and was detected by Mr. Whitaker during a visit he paid with me to the pit.

Though these veins are insignificant now, shells were noticed in 1826 by S. Woodward,* and again in 1865, when the shell-bed was stated to be 3 or 4 feet in thickness, and the usual marine shells to be abundantly found in it.†

The only recognizable species I obtained were *Trophon antiquus* from the upper bed, and *Cardium edule* from the lower bed. *Calyptræa Chinensis* has, however, been recorded,‡ and Mr. H. Norton obtained from the workmen a specimen of Astarte (*A. sulcata?*). Mr. J. E. Taylor noticed here a bed of Iron-pan.§

The following is the section (*see* p. 134, and Fig. 24, Plate VIII.):—

		Feet.
Warp		2 to 3
Shingle and sand		10
Crag Series	Hardened sandy clay with fragments of shells	½
	Sand with streaks and bands of clay	6
	Laminated clay	3
	Stone-bed with shells	½
Chalk.		

In the escarpment west of Crown point the pebbly sands are locally hardened into stone.

South-east of Trowse Hall a pit showed about 15 feet of pebbly gravel, sands, and laminated clays, the sands and gravel chiefly at the top.

Whitlingham.—Numerous pits have been opened for the working of Chalk at Whitlingham, which have exposed the Crag, in one opening of which the famous tooth of Mastodon, figured by William Smith, was obtained.‖

Two pits were being worked during my examination of the district (1875–1878), and in both of them the shell-beds have been exposed.

The larger one situated to the east displayed at one time a remarkable disturbance in the Chalk (*see* p. 134).

The structure of the beds is exceedingly variable.

One face of the larger pit showed (in 1875) the following section:—

		Ft.	Ins.
Upper Crag.	Pebbly sands and gravel	8	0
	Shelly bed, 6 in. to 1 ft., impersistent Brown clay, a few inches	1	0
	Light-coloured sand	0	6
	Clayey seam	0	2
	Sand	4	0
	Sandy clay	3	0
	Sand and gravel	1	0
	Shell-bed	1	6
	Stone-bed	1	6
Chalk.			
		20	8

* Letter to J. W. Robberds, 17 October 1826.
† Norwich Mercury, 20 May 1865.
‡ Proc. Norwich Geol. Soc., vol. i., p. 5.
§ Geol. Mag., vol. ii., p. 370.
‖ Strata identified by Organized Fossils.

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The following section of the Crag series in the same pit at Whitlingham, which was taken in 1877, is represented in fig. 9, Plate III. :—

	Feet.
4. Pebbly gravel and sand, with seam of shells - - -	15 to 25.
3. Laminated clay and seam of shells - - - -	
2. Sand and pebbly gravel with patches of shells - - -	
1. Stone-bed - - - - - - -	
A. Chalk.	

This section showed one of the lenticular masses of laminated clay sometimes called "Chillesford Clay"; it overlaid a bed of shells, and was itself overlaid by two beds, one of which it perhaps partly replaced. At this time (1877) the eastern face of the pit showed no distinctive clay-band at all, and while at one time it exhibited a small nest of shells, on a subsequent visit this was quite worked away. This pit alone shows that no distinctive horizons can be traced out in the Upper Crag by the occurrence either of shell-beds or of laminated clay. Diagrams drawn at different times, as the beds are worked away, are quite different in detail. This is one of the charms of Norfolk geology, for there is always something fresh to be seen in the sections of the Pliocene beds, as well as in those of the Pleistocene or Glacial accumulations. In my "Geology of England and Wales" (1876), p. 287, is an illustration of this pit, engraved from a photograph (taken about the year 1868) kindly lent to me by Mr. Bayfield. I then divided the beds according to the classification of Mr. S. V. Wood, jun. Experience gained subsequently in this pit shook my confidence in the permanence of any of these local divisions, for at different times they would be made at various horizons. The shells likewise belong as much to the so-called "Bure Valley Beds" (4), as they do to the lower portions of the Norwich Crag Series.

The smaller pit to the west showed the following beds:—

Upper Crag - { Pebbly sands. / Laminated clays and sand. / Shell-bed.

Chalk (gently undulating).

From these pits the shells noted in the accompanying list (*see* p. 42) were mostly obtained by myself. The specimens of *Astarte incrassata* and *A. sulcata* I found in the smaller pit. Mr. J. E. Taylor found also at this locality *Cardium Grœnlandicum* and a species of *Venus* in a bed of shells about 4 feet in thickness, resting on a seam of Iron-pan.*

As before mentioned I have noticed no less than three distinct shell-beds in the larger pit. And in a section given by Mr. R. C. Pitt, in 1840, four beds with shells were then visible.†

Arderon, who in mistake described the locality as "Cantley White House," 3 miles south-east of Norwich, from the evidence of the shells, remarked, "These hills I take to have been formerly the boundaries to an arm of the "sea, which made Norwich a famous seaport."‡ The idea of the present valleys having any connection or correspondence with the Crag seas or bays was disproved many years ago by R. C. Taylor; it has now been revived by Mr. S. V. Wood, jun., though I believe it is entirely opposed by the evidence of pits and well-sections.§

The Rev. T. Clowes "found in a perforation in the Chalk at Whitlingham "the shell of a *Pholas crispata*, the remainder of the perforation being filled with Crag."‖

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* Geol. Mag., vol. ii., p. 370. This bed Mr. Taylor then spoke of as Glacial Drift.

† Proc. Sci. Soc. Lond., vol. ii., p. 5.

‡ Phil. Trans., 1747, No. 481, p. 279.

§ Quart. Journ. Geol. Soc., vol. xxxvi., p. 461.

‖ Lyell, Mag. Nat. Hist., vol. iii., p. 316; Proc. Geol. Soc., vol. iii., p. 128.

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Kirby Bedon.—Shells were noticed in this parish by S. Woodward and J. W. Robberds,* about half a mile from the Woods End House on the road towards Kirby Bedon Church. They were noticed by the former "at the "bottom of a fence opposite the Farm House;" and in the banks between it and the Woods End House, both Crag shells and remains of Mammalia have been observed. The shells were at one time opened up in a pit by the road side, but the patch was worked away.†

More recently Mr. J. E. Taylor pointed out the abundance of *Loripes divaricata*, of which he obtained 28 specimens in two visits.‡ *Calyptræa Chinensis* is also abundant. Mr. Reeve has collected among other shells a new species of *Nassa*.§

The list given in the table, p. 42, includes the species obtained by Mr. Reeve and Mr. Taylor, as well as others collected by Mr. S. C. Sothern and myself.

Bramerton.—The pit on Bramerton Common, though now far inferior in its exhibition of the beds to either Whitlingham or Thorpe, has always been treated as a sort of typical section of the Norwich Crag.

The section is as follows:—

	Feet.
Very fine sand with gravelly seam at base	1 to 2
False-bedded ferruginous sand with pebbles of flint, quartz, &c.	2
Blue and brown mottled clay‖	1
Sand with shells. Zone of *Astarte borealis*	2
Seams of brown clay	20 or 21
Sand with a few stones and shells sparingly (about 12 feet)	
Seams of brown clay (6 ins.)	
Shell-bed with seams of brown clay (about 6 feet)	
Bed of flints (1 foot) with Mya in natural position	
Chalk with flints (about 2 feet above the river-level).	
	about 27 feet.

R. C. Taylor, who described the section in 1823, gave a thickness of 50 feet for the Crag, and mentioned three distinct beds with shells.¶ Samuel Woodward** gave the thickness as 60 feet, and his account varied very much from Taylor's. Indeed every section taken at intervals must vary as the beds themselves are so changeable. I am entirely unable to agree therefore with the special correlation made with the beds at Chillesford and elsewhere. In a large way the beds correspond, but it is impossible to correlate minute divisions which change as the beds are worked away. (*See* pp. 33–36.)

Bramerton has always been the chief collecting ground. Sowerby's specimens were nearly all obtained from this locality; so also were those enumerated by Mr. S. V. Wood in his "Crag Mollusca." *Tellina Balthica* therein recorded by him, has been subsequently regarded as an erroneous statement: it has never been met with by Mr. James Reeve during his exhaustive examination of the beds. To Mr. Reeve indeed we are mainly indebted for our present knowledge of the Bramerton Crag fauna. *See* table, p. 41.

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* Robberds, Eastern Valleys of Norfolk, 1826, p. 14.

† S. Woodward, MS. Sketch of the Norwich Crag Deposit, 1825.

‡ Norwich Geol. Soc. 1866.

§ Quart. Journ. Geol. Soc., vol. xxvii., p. 458.

‖ This is the bed sometimes identified with the Chillesford Clay. Mr. Prestwich, however, says that this clay was not visible when he saw the pit, but he found traces of it in the road leading up the hill at the back of the pit. Q. J. G. S., xxvii., p. 457. *See also* Wood. *Ibid.*, xxxvi., p. 459.

¶ Trans. Geol. Soc., ser. 2., vol. i., p. 372, and Plate 47.

** MS., 1825.

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"A large mass of Chalk was found at the foot of the Cliff at Bramerton by the Rev. W. Foulger, perforated by the *Pholas crispata*, 3 inches in diameter."* Similar borings were also detected by the Rev. T. Clowes.†

Hydrobia subumbilicata has been found in some abundance in the lower bed on Bramerton Common by Mr. Reeve, but so far as I am aware all of the freshwater shells are very rare. Sections of the pit on Bramerton Common have been published by Mr. S. V. Wood, jun., in his Remarks in Explanation of Map (1865), Sec. 24; and in conjunction with Mr. F. W. Harmer, in the Supplement to the Crag Mollusca, Sec. XVI.

Shells were noticed further east, as far as the boundary with Surlingham parish, by J. W. Robberds;‡ and by S. Woodward "about 300 yards lower down "the river by the side of a cottage."§ This would be about the spot where we now find the excavation known as "Blake's Pit," to which Mr. J. Reeve directed attention in 1870.‖ The Crag here is often called the "Scrobicularia bed," from the abundance in it of *Scrobicularia plana* (*piperata*). Mr. S. V. Wood says it "appears to intervene between the few feet of specially Fluvio-marine "Crag which rests on the chalk and the Chillesford bed."¶ For my own part I cannot recognize such a distinction. Blake's pit shows a mass of shells and sand from top to bottom, with included streaks of clay. The *Scrobicularia* so abundant here is very rare in the adjoining exposures on the Common. Many of the shells are highly stained with iron-oxide in Blake's pit, and present quite the appearance of Red Crag fossils.

Pebbly gravels are exposed south of the church by Bramerton Low Common.

South of Holverston Thicks there was shown 4 feet of false-bedded brown and yellow sand.

Surlingham St. Saviour.—N.E. of the church a pit showed false-bedded sand and gravel, and at the adjoining brickyard sand only had been dug, the clay being brought from Rockland.

Surlingham St. Mary.—South-east of the church are pits dug in brown and yellow sand (9 feet).

North of the church a pit showed:—

		ft.	in.
Upper Crag	Pebbly gravel	1	0
	Sand	0	8
	Bluish-brown clay with seams of sand	2	0
	False-bedded orange-coloured sand, with occasional pebbles of quartz and flint	10	0
	Sand with beds of laminated clay	4 or 5	0
	White and orange-coloured sand	1	6

Higher up the hill pebbly sand and gravel were cemented in places into a pudding-stone.

South of the Barn (north of the road) a pit showed 15 feet of white and buff sands and pebbly gravel, with streaks of laminated clay and fine gravel, below which about 4 feet of blue and brown laminated clay has been worked, and beneath it was exposed 3 feet of white and yellow sand. Immediately south of the road, there were several excavations showing 6 to 8 feet of false-bedded sand, gravel, and loam, much weathered at the surface (? rainwash), resting on irregular mottled clay (1 foot), and laminated clay and sand (1 foot to 3 feet). At the western opening (close to where the three roads meet) there were traces of Chalky Boulder Clay. (*See* p. 111.)

North of Surlingham Wood a pit showed about 11 feet of brown and yellow sands, with a vein of laminated clay in the middle. In the lower part iron-stone nodules occurred, also white sand with fragments of shells.

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* S. Woodward (MS.) 1825.
† Letter to S. Woodward, 28 April 1837.
‡ Robberds, Eastern Valleys of Norfolk, p. 10.
§ MS. Sketch of the Norwich Crag Deposit.
‖ Norfolk News, Oct. 8, 1870.
¶ Second Supp. to Crag Mollusca (Pal. Soc.), p. 35.

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In 1873 Mr. Gunn drew attention to the discovery of a Mastodon's tooth in the beds in a pit near Surlingham Wood; and in the same year I had the advantage of seeing the pit with him, and in company with my colleagues Messrs. F. J. Bennett and W. A. E. Ussher.

The following was the section then recorded by Mr. Gunn :—

	Feet.
7. Gravel, from which a Neolithic implement was taken.	
6. "First-rate Chillesford Clay" - - - -	10
5. Bright yellow sand in which the tooth was found - -	3
4. Red gravel.	
3. Lighter coloured clay with large interspaces of sand, beautifully laminated - - - - -	8
2. "Chillesford Clay" more compact, and the lower part of a darker bright blue colour - - - - -	10
1. Fine sand in which shells were found 6 feet below the clay.	

Associated with the tooth were broken fragments of a leg bone of the Mastodon or Elephant. The tooth bore a matrix of dark coloured gravel and sand, thus differing from the sand in which it was found. Mr. Gunn considered that it was derived from the Stone bed.*

The following was the section of the pit when I visited it in 1877. (*See* fig. 11, Plate IV.) :—

		Feet.
Upper Crag -	5. Warp - - - - -	2 to 3
	4. Brown clay, sand, and gravel, contorted	5
	3. Sand in which bones had been found -	1 to 2
	2. Laminated clay and sand - -	10 to 12
	1. White false-bedded sand.	

Rockland.—About 40 yards north of the "White Earth Pit," Rockland, a sand pit was opened to the depth of 20 feet. (*See* p. 112.)

North-west of the Staith, by the New Inn, a pit showed 3 to 5 feet of stony loam (? Contorted Drift) resting on 9 feet of pebbly gravel and sand.

The brickyard by the New Inn showed 5 feet or more of buff false-bedded sand with thin layers of laminated clay, capped by 7 or 8 feet of pebble gravel, abutting against which was a mass of Chalky Boulder clay with included beds of sand and laminated clay. The Boulder Clay was formerly used for brick-making, but this was discontinued four or five years ago, and now the clay is obtained from Surlingham Wood Pit.

North-east of Rockland Hall the following beds have been opened up :—

		Feet.
Glacial Drift?	- Loam and gravel - - - -	3 to 5
Upper Crag -	Buff false-bedded sand and fine gravel, with laminæ of clay and clay-pebbles - -	15
	Stiff blue slightly micaceous clay - -	5
	Sand.	

I obtained a piece of granite from the Crag.

Some of the clay-pebbles were coated with iron-oxide, and it seems probable that they give rise to the concretionary masses which contain nuclei of iron-ochre (*see* p. 38). The Blue Clay burns to a red brick, differing thus from the celebrated clay of Rockland of Glacial age, which burns to a white brick. My cousin, Mr. B. B. Woodward, kindly examined these clays microscopically, but was unsuccessful in finding any organic remains in them.

Hillington.—Between the Star Inn and the Common, 6 feet of laminated clay and sand have been opened up, and the same beds probably were used for brickmaking a little further east in Claxton parish.

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* Meeting, Norwich Geol. Soc., March 4, 1873, reported in the Norwich Mercury.

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Claxton.—A pit by the Mill west of Carlton Broad, showed 12 feet of gravel and false-bedded sand (? Valley gravel).

A pit by the *H* of Claxton Hall (on the map) showed 5 feet of buff false-bedded sand.

Carlton St. Peter.—North-east of the Church a pit showed 8 feet of rather loose rudely-stratified gravel and sand, which, at the time, I was disposed to regard as possibly valley gravel. North-east of the Broad about 20 feet of false-bedded sand and fine gravel, composed chiefly of flint and quartz, has been opened up. In this district we come into contact further on, with pebbly gravels in the Glacial Drift, much like those in the Crag series, and it is possible that the various exposures have not always been correctly represented on the Geological Survey Map, especially where the Glacial and Pliocene gravels come together without the intervention of the Lower Glacial brick-earth.

Burgh Apton.—South-east of the church a pit showed buff and brown sand, with seams of micaceous clay and pebbly gravel, also clay-pebbles.

East of Park Farm a large pit showed 40 feet of gravel containing quartz and quartzite, and some large flint boulders.

Mundham St. Peter.—West of Tyler's Hill, a pit showed sand and pebble gravel with bands of laminated clay.

Pebbly gravels of the Upper Crag stretch through Loddon to Heckingham, where they have been mapped by Mr. Reid, beyond which they have not been identified. At one time I was of opinion that the pebbly gravels exposed near Nogdam End were of the same age, while Mr. Reid had included the pebble beds of Haddiscoe in the "Bure Valley Beds." Subsequently I was enabled at Chedgrave and Hardley Hall to find evidence of pebbly gravels in the Glacial Drift overlying stony loam (Lower Glacial). The Haddiscoe gravels, moreover, were shown in section to be intercalated with the Glacial sands of that area, hence these beds, with which the pebble beds of Halesworth, Henham, and Westleton are correlated, are distinct from the Pliocene "Bure Valley Beds," which I group with the Upper Crag.*

IV.—Waveney Valley.

The following notes are by Mr. Clement Reid:—

Woodton.—A pit opposite the Meeting House showed quartzose pebbly gravel, capped by Valley Gravel and a wash of Chalk flints. In the pit further south about 20 feet of gravel was shown. The upper portion, comprising coarse loamy River Gravel, rested upon fine false-bedded pebbly gravel and sand, in the lower part of which was a good deal of greenish clay. About half the pebbles were of flint, the rest consisted of hard sandstone, quartz and quartzite. One pebble of pudding-stone occurred. (*See* p. 108.)

Bungay.—A pit at Duke's Bridge showed subangular gravel with *Purpura lapillus* and *Mya* sp. At Bungay Station behind the goods shed Shelly Crag is said to occur.

C. Reid.

Ditchingham.—In the year 1832 Daniel Stock, of Bungay, forwarded to S. Woodward a few fragments of shells which he had picked out of a bed at the foot of the Bath Hills. He observed that it was very difficult to procure a perfect specimen.† Mr. Reid obtained many shells in a bed of pebbly gravel and sand exposed in the kitchen garden of Ditchingham Lodge. He was informed that Shelly Crag occurred at the targets on the Bath Hills.

A full list of shells obtained at Ditchingham is given in the table, p. 42, but it seems desirable to separate those obtained from two spots in the parish, and to give the following detailed account:—

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* *See* S. V. Wood, Quart. Journ. Geol. Soc., vol. xxxvi., pp. 468, 464; and F. W. Harmer, Geol. Mag., vol. vi., p. 234.

† Letter to S. W., 19th June 1832.

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List of Fossils from the Crag at Ditchingham.

A. A few species marked * are mentioned on the authority of Mr. S. V. Wood, all the other species were obtained by Mr. Clement Reid in the pit at the back of the kitchen-garden at Ditchingham Lodge. A few species were also obtained by Mr. Hartcup from a deep well at Mrs. Menzie's house, Ditchingham. (*See* p. 158.)

B. Those marked ‖ are in the possession of Mr. Hartcup, the rest were obtained by Mr. Reid from the porter at the Hospital.

vc = very common. *vr* = very rare.
c = common. *r* = rare.

	A. Bath Hills.†	B. Hospital.
Buccinum undatum, var. tenerum	—	r‖
Cerithium tricinctum	c	c
Hydrobia (Paludestrina) subumbilicata	—	r
Litorina litorea	vc	vc
——— rudis	—	r
Natica catena	vc	r
——— helicoides	r	—
Paludina media	r	r‖
Purpura lapillus	vc	vc
Scalaria Grœnlandica	r	—
Trophon antiquus	r	—
——— ——— var. contrarius	*	—
——— ——— var. striatus	*	—
——— scalariformis	—	?
——— gracilis	—	‖
Turritella incrassata	c	r
——— terebra	*	—
Voluta Lamberti	—	columella‖
Astarte compressa	r	—
Cardium edule	vc	vc
——— Grœnlandicum	r	—
Corbula contracta	*	r
——— striata	r	r
Cyprina Islandica	c	r
Leda oblongoides	r	—
Lucina borealis	c	r
Mactra ovalis	c	?
——— subtruncata	c	—
Mya arenaria	c	c
Mytilus edulis	vc	c
Tellina lata	r	‖
——— obliqua	vc	vc
——— prætenuis	c	r
Scrobicularia plana	—	vr
Balanus	r	r
Fish vertebræ	r	—

Broome.—"A pit north of Broome Street appears to be in pebble beds with a little Lower Boulder Clay?"†

Geldeston.—"A pit south of the Church showed about 20 feet of pebbly "gravel."†

Aldeby.‡—The section at Aldeby showed in 1878, from 6 to 8 feet of sand and fine gravel (Valley Gravel) resting on 6 feet of laminated clay and sand. Beneath this occurred the shell bed, which was opened up to a depth of about 5 feet. The laminated clay is generally correlated with the Chillesford Clay.

† From Mr. C. Reid's notes.

‡ This section when first described was stated by mistake to be in the parish of Toft Monks. Lyell speaks of the Crag at this locality as the Aldeby beds. *Student's Elements* (1871), p. 168.

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The fossiliferous bed was first brought into notice by Mr. C. B. Rose in 1865, who identified it as Norwich Crag.*

It is, however, almost entirely owing to the labours of Messrs. W. M. Crowfoot and E. T. Dowson that the rich fauna recorded in the table, p. 41, is known to us.

Mr. Dowson very kindly furnished to Mr. Reid the following notes of the pit, dated October 28th, 1867:—

West Part.	ft.	in.
Warp	0	9
Gravel	3	6
Loamy sand	7	0
Laminated clay	6	0
Sand without shells	0	9
Shell bed	1	6
Sand	1	0

Central Part.	ft.	in.
Warp	1	0
Coarse gravel	2	6
Loamy sand, with thick veins of laminated clay	7	6
Laminated clay	6	9
Sand without shells	0	9
N.B.—A large flint, ¾ cwt., mentioned by Mr. Prestwich, came from the sand about here.†		
	ft.	in.
Shell bed	2	0
Sand, with veins of clay and a few fragments of clay, to water level	4	3

East Part.	ft.	in.
Warp	1	0
Sand	1	0
Coarse gravel	2	6
Laminated clay without chalk or flints	3	0
Sand without shells, but with a few large flints	3	3
N.B.—A little further E. a thin vein of shells appears.		
	ft.	in.
Shell bed with Cyprina (perfect), &c.	0	3
Sand, with a few fragmentary shells and thin seam of clay: to water level	3	6

A boring was made at the extreme east end of the section, in November 1867. A thickness of sand and Crag (fragmentary), and perhaps a few small seams of clay, were bored through to the extent of about 10 feet beneath the water level, and gravel was then reached, which the boring-tool unfortunately would not pierce.

[E. T. D.]

The following notes on the section exposed (1875–76) are by Mr. C. Reid:—

		Feet.
	Run of the hill	3 or 4
	Valley gravel	3
Upper Crag	Brownish bedded brickearth rather sandy passing into—	6
	Laminated bluish clayey brickearth	6
	Sand.	

A few yards further west the section was:—

		ft.	in.
	Soil	1	0
	Valley gravel	5	0
Upper Crag	Sand, with occasional seams of pebbles	4	0
	Loamy brickearth	4	0
	Clayey do.	6	0
	Brown sand, with line of *Tellinas* 8 inches down, and another at 1 foot 6 inches	2	0
	Bed full of upright *Mya arenaria*	0	5
	Light brown sand with scattered shells	1	4

* Rep. Brit. Assoc. for 1868, Trans. of Sects., p. 77. *See also* Quart. Journ. Geol. Soc., vol. xxii., p. 545.

† *See* Quart. Journ. Geol. Soc., vol. xxvii., p. 454.

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	ft.	in.
Shell bed, *Astarte*, *Mactra*, perfect *Cyprinas*, &c., and occasionally large unworn flints -	0	2½
Band of blue clay - - - - -	0	0½
Loamy brownish sand - - - -	1	0
Hard brownish brickearth with scattered shells - - - - -	2	0
Sand - - - - -	?	

Barsham.—A pit west of Barsham Church showed orange-coloured sand with scattered pebbles. The road above showed loamy beds.

N.E. of Ashmans, a pit showed about 18 feet of fine sand, with a seam of gravel.

One quarter of a mile W. of Roos Hall, the following section of Upper Crag beds was to be seen :—

	ft.	in.
Soil - - - - - - - - -	1	0
Sand, with scattered worn and subangular stones (flints, quartz, &c.), the lower part false-bedded - - -	6	0
Ferruginous shingle of flint and quartz pebbles, with a few subangular stones - - - - - -	1	0
Yellow sand, with some carbonaceous matter and small scattered pebbles - - - - - -	0	8
Loamy shingle - - - - - -	1	0
Bedded white and yellow loam, not so well laminated as the Chillesford Clay at Aldeby, and rather more sandy; stones very scarce - - - - - - -	6	6

Beccles.—On the London road, E. of the first mill from Beccles, mottled orange loam with gravel and thin seams of clay, like the Chillesford clay, was shown in the road-cutting.

At Ingate Clay Pit the following section was exposed :—

	ft.	in.
Soil (sandy) - - - - - - - -	2	0
Pebbly sand - - - - - - - -	3	0
Loamy Chillesford clay, upper part brown, lower blue and stiffer; a good many thin ferruginous seams occur, which have to be separated before it is used for bricks; there is also too much sand, which lowers its economic value -	14	0
Hard pan and sand.		

A sandpit on the Beccles racecourse showed fine brown and white sand and loam, with carbonaceous grains and false bedding, 10 feet, capped by gravelly Alluvium, and near the water, by Boulder Clay.

In the basement of Mr. Pearce's shop, Blyburgate Street, Beccles, was exposed sandy laminated loam with seams of sand. In the road opposite there is laminated loam with pebbles.

C. Reid.

The two deep borings at Beccles recorded by Mr. W. M. Crowfoot (*see* p. 156) show at least 95 feet of strata, which belong to the Upper Crag; perhaps portions of the "Gravel and sand, with broken shells" grouped with the Bure Valley Beds may be Upper Crag also.

The shells obtained by Mr. Crowfoot are given in the table, p. 42.

Mr. S. V. Wood observed that the well probably "pierced the same bed as "that not far away at Aldeby, though it has a Fluvio-marine aspect."*

* Supplement to the Crag Mollusca, 1872, p. 61.

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The following is the abbreviated section of the beds below the Middle Glacial Drift, given by Mr. Crowfoot:— *

		First well.		Second well.	
		ft.	in.	ft.	in.
Bure Valley Beds.	Gravel and sand, with broken shells - - -	32	0	33	0
Chillesford Clay.	Loamy micaceous sand -	14	0	15	0
Chillesford Sand.	Red sand with shells - -	12	0	14	6
Fluvio-marine Crag.	Dark sandy clay and silt, full of shells - -	68	0	65	6
		126	0	128	0

Chalk.

Mr. Crowfoot mentioned that these "Chillesford Sands" yielded *Cardium edule, Tellina fabula, T. prætenuis, T. obliqua, Mactra ovalis, Mya, C rithium tricinctum,* and *Litorina litorea.* For further details of the beds, *see* p. 156.

"The 'Chillesford Beds' were well exposed at the northern end of Bonaparte's Island, a boss bounded by river-gravel on the east, south, and west, and overlooking the Beccles fen on the north. They were also exposed in sewer-cuttings in the northern streets of Beccles in 1879. They occurred in the usual form of tawny sands with grey clay bands."†

* Proc. Norwich Geol. Soc., vol. i., p. 76.

† From Mr. W. H. Dalton's Notes.

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CHAPTER IV.—GLACIAL DRIFT.

General Remarks.

In passing from the Pliocene to the Glacial beds, we turn from deposits that on the whole maintain considerable uniformity in character and position, to beds which in both respects are subject to great variations.

Looked at in a broad way, the following is the succession of the beds:—

		Feet.
Glacial Beds.	4. Plateau Gravel. Coarse "cannon-shot" gravel and sand	1 to 45
	3. Chalky or Upper Boulder Clay. Chalky clay, with numerous stones and occasional boulders	1 to 50
	2. Sand and Gravel	1 to 25
	1. Lower Boulder Clay or Contorted Drift. Stony loam or brickearth	1 to 35
Pliocene Beds.		

In the classification of Messrs. Wood and Harmer, bed 1 is placed as Lower Glacial, bed 2 as Middle Glacial, 3 as Upper Glacial, and 4, doubtfully, as Post Glacial.

In certain localities and over limited tracts of ground, it is true, the entire succession may be traced out, as near Strumpshaw Hill, Moulton, Upton, and South Walsham: nevertheless, so irregular are the deposits in the area under consideration that the evidence of this order is the exception and not the rule.*

The contorted drift (1) and sands and gravel (2) are sometimes so intimately connected, as near Smallburgh, Plumstead, Panxworth, and Sprowston, that it is not easy to separate them, or to say whether certain masses of sand are included in the brickearth or overlie it.

Again, the sands and gravel (2) are oftentimes not to be separated from coarse gravel, like that which belongs to group No. 4.

It is indeed most difficult to correlate the sands occupying the plateaux between Norwich, Eaton, and Earlham, for the Chalky Boulder Clay of Mackie's Nursery seems to wedge into them, being distinctly underlaid and overlaid by sand. Again, west of Cringleford, the Boulder Clay occurs as a wedge in the sand.

The section at Hethersett shows that fine buff sand, like the so-called "Middle Glacial" of Mousehold, may be intercalated in the coarse plateau gravel that overlies the Chalky Boulder Clay; it likewise occurs in the Boulder Clay itself, at Keswick and many other places. There appears to be no deposit sufficiently regular in the area to warrant the use of the term "Middle Glacial;"† both the Chalky Boulder Clay and the Lower Glacial Brickearth are associated with beds of gravel and sand; and

* *See* remarks by G. Maw, Geol. Mag., vol. iv., pp. 97, 276, 427.

† Mr. Penning agrees that between the Lower and Middle Glacial there is "no definite line of demarcation." Quart. Journ. Geol. Soc., vol. xxxii., p. 195.

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on the whole the classification suggested by Mr. Jukes-Browne* appears to me the most applicable to the district under consideration :—

Upper Glacial -	Plateau gravel.
	Chalky Boulder Clay.
Lower Glacial -	Sands and gravel ("Middle Glacial" in part).
	Stony loam or brickearth (Contorted Drift).

Between these two divisions may be placed the Brandon beds described by Mr. Skertchly. Whether or not they are represented in the district, cannot at present be absolutely determined, but I am disposed to classify with them certain blue clays worked at Rockland and Surlingham. (*See* p. 110.)

In regard to agriculture the Glacial Drift plays a most important part in Norfolk. It occupies a larger portion of the district described than any other formation, and its relation to the surface soil is generally intimate.

Strewn about the surface of the ground are occasional large boulders, often placed by the road side to protect exposed corners of buildings. To enumerate them would serve no practical or scientific purpose.

The following were noticed by Mr. C. Reid :—

On the high road near Wash Farm, Denton, is a boulder of bluish-grey sandstone, 4 feet in length; a quarter of a mile south of Barsham Church is a Greywether,† 4 feet long; by the road side at the northern end of Alburgh Street is a subangular block of dark coloured grit over 3 feet long.

At West Hapton I noticed a boulder 5 feet by 3; but was unable to determine the rock.

Most of the large boulders have been taken out of the Lower Boulder Clay, or have been turned up during the ploughing of land in tracts where this formation is uppermost. These have been, many of them, removed to the adjacent village or homestead to serve some useful purpose.

A.—Stony Loam or Brickearth (Contorted Drift).

This deposit consists generally of a brown stony loam, containing a few flints, and rarely large boulders of greenstone, granite, and other igneous rocks. It is termed the Lower Boulder Clay by Mr. Gunn, and varies from 1 to 35 feet in thickness.

Pellets of Chalk and patches of very chalky clay appear in it in many places, and towards Cromer and further west, near Weybourn, these marly beds are worked for lime.

The beds are sometimes well stratified and even present appearances of lamination, but very often inland as well as in the

* The Post-Tertiary Deposits of Cambridgeshire, 1878, p. 79; *see also* Proc. Norwich Geol. Soc., vol. i., p. 58.

† Blocks like the Greywethers of Wilts and Berks are sometimes formed in the Drift sands. (*See* p. 93.)

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coast sections they exhibit many and remarkable contortions; hence the term Contorted Drift, applied by Lyell.

These contortions include masses or "Galls" of sand and gravel, and it is not unfrequently very difficult to distinguish between them and the so-called Middle Glacial beds.

Both the loam and the nests of sand included in it, often contain shells, chiefly in a fragmentary condition. The most abundant species are *Tellina Balthica, Cardium edule, Cyprina Islandica,* and *Mya arenaria.*

From its mixed nature the land where this drift is exposed is of the highest agricultural value, as in the parishes of Ludham, Barton, Tunstead, Scottow, Plumstead, and Hamlington.* The soil is a rich loam, containing a variable amount of calcareous matter. By Mr. C. S. Read it is grouped among the "naturally good soils."†

Comparatively few sections are to be seen in the area, for it is only where the earth becomes sufficiently "strong" or clayey to be useful in brickmaking, that the beds are opened up. Near Tunstead especially one may traverse many a mile without seeing a section.

Brickmaking, however, is the chief economic application of the strata. Tiles and pipes are occasionally made from the "stronger" kinds of earth.

B.—Sand and Gravel ("Middle Glacial").

These beds of sand and gravel are of variable nature and composition. Sand more often predominates, and it is generally of a pale buff colour and very finely false-bedded. Fragments of shells are met with here and there; and specks of comminuted lignite or "coal smut" are abundant.

The gravel often contains a large number of transported fragments, pebbles of quartz, many varieties of sandstone and quartzite, and some igneous rocks; but it is chiefly made up of flint in the shape of pebbles and sub-angular stones. The sand is used in the brickyards, and for mortar, and the gravel is employed for mending roads and paths. The beds attain a thickness of 25 feet. Agriculturally the soil is the least fertile in the area, but in some localities it is covered with a foot or two of loam (possibly a relic of Chalky Boulder Clay), which, of course, renders it of much higher value. On not a few farms the soil is liable to be blown about. Hence Mr. Read's term of "Blowing Sand" is very appropriate.

It forms heathy tracts, rabbit warrens, and sheep walks, and is here and there planted with firs, as at Felthorpe and Horsford. It is, however, difficult to say whether the extensive masses of sand in these parishes, often capped by gravel, should be regarded

* In my address to the Norwich Geol. Soc., 1879, Proc. N. G. S., vol. i. p. 100, I included also Burlingham, but I have since ascertained that the Chalky Boulder is developed there, covered by a loamy soil much like the Lower Glacial Brickearth.

† Article in White's History and Directory of Norfolk, 1864.

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as entirely older than the Chalky Boulder Clay. At Mackie's Nursery the Boulder Clay seems intimately connected with the sand, but just beyond the north-western corner of the area Chalky Boulder Clay was to be seen resting on the sands in the cutting by Cawston Railway Station. At Haveringland the sand is covered with Boulder Clay. Hence, on the whole, the evidence is in favour of much of the sand being older than the clay.

The frequent occurrence of masses of indurated sand or "doggers" beneath the Chalky Boulder Clay is well known. Probably the most familiar instance is at Mackie's Nursery (*see* p. 121).

Mr. J. E. Taylor pointed out the occurrence of similar beds near Loddon, Thurton, Langley, Chedgrave, and Hales. That at Hales was 4 feet in thickness. "In each case this stone occurred directly beneath the Upper Boulder Clay, or 'heavy land,' and Mr. Taylor assigned its consolidation to the limy matter which had been carried through the clay by percolation."* Other instances will be referred to in the sequel.

Mr. G. Maw has described blocks that have become consolidated in the drift of Suffolk, and which resemble Greywethers.†

Local Details.

1. *Area North of the Yare.*

Haveringland, Cawston.—The boundaries of sand and brickearth near Haveringland Hall, Crow Hall, and Beck Barn are indefinite.

Marsham.—A pit E. of Fifty Acre Plantation showed the following beds :—

		Feet.
Lower Glacial	Brown and buff sand and fine gravel	3
	Coarse gravel	1
	Buff false-bedded sand	3
	Brown brickearth	6 (shown).

Hevingham.—North of Dark Plantation a brickyard showed 10 feet of brickearth.

Haynford.—A brickyard S. of The Lodge showed 6 feet of stiff blue and brown brickearth.

Horsford.—The heath is situated on fine gravel and sand. At Sharpe's Hall 5 feet of sand was exposed in digging the pond.

Felthorpe.—A pit S.W. of the Church showed 8 feet of stony loam. South-east of the Hall Farm a pit showed 8 feet of buff and white sand.

Attlebridge.—*See* p. 118.

Taverham.—North of the fifth milestone on the Norwich and Drayton Road, the sand is sometimes blown off the fields.

Drayton.—South of Bugg's Grave a brickyard showed at top, 12 to 14 feet of buff sand slightly false-bedded : beneath, the beds worked were about 8 feet of brickearth, containing a vein of chalk stones.

The lane S.E. of Bugg's Grave, running eastwards from Drayton, showed 7 feet of laminated brickearth.

Hautboys.—East of the Hall the railway-cutting exhibited stiff clay and stony loam with traces of marl like Chalky Boulder Clay, resting in hollows of the Crag sands.

Hoveton St. John.—Traces of stony loam may be seen on the Crag series in the cutting N. of Wroxham Station.

Sco-Ruston.—North of the Church sandy brickearth has been worked. A quarter of a mile to the east, 4 feet of brown and yellow sands were exposed, and

* (Norwich Geol. Soc.), Norfolk News, June 11, 1870.

† Quart. Journ. Geol. Soc., vol. xxiii., p. 110.

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there was no evidence to show whether these belonged more properly to the Glacial beds or to the Crag series.

Tunstead.—North-west of the Dairy-house (in the parish of St. Peter's, Hoveton), 5 feet of buff sand was exposed, and this evidently belonged to the Glacial Drift, being perhaps a nest of sand. There are, however, few sections in this neighbourhood, and it is difficult here and further E. to map distinctly the sands which occur on the brickearth.

Smallburgh.—North-east of Cat's Common 8 feet of buff sand has been exposed.

Barton.—To the S.E. of the Hall Farm a pit exposed 6 feet of tile-earth. To the W. of the house 20 feet of sand had been penetrated. East of the Hall 3 feet of white sand was exposed. The Green showed excavations made in brickearth.

Ludham.—On How Hill a pit showed 15 feet of buff false-bedded sand.

At the Mill the section in a brickyard was as follows (1877):—

Gravelly soil.
Sands and gravelly brickearth, 5 feet.
Buff sand.

Sutton.—In an analysis of soil at Sutton-near-Stalham, Dr. Lyon Playfair mentioned the occurrence of 2 per cent. of chloride of sodium, due to the proximity to the sea.*

The following notes are by Mr. BLAKE:—

Thurne.—A clay and loam pit is situated on the S. side of the road, about 150 yards S.W. of Thurne Church. The section exposed showed 9 feet in thickness of chalky Boulder Clay of a grey colour, overlying 9 feet of grey and brown loam, which latter contained numerous little pieces of Chalk variously scattered throughout its mass, with irregular thin lenticular sandy patches, also white streaks, &c., consisting of grains and small pebbles of Chalk. The section was much overgrown, but from what I could see, the loam approached the chalky Boulder Clay so much in character that the two formations presented the appearance—as observed elsewhere—of blending or merging one into the other.

In a small sand pit about 60 yards N.E. of Thurne Church, adjoining the churchyard, 6 feet in thickness of buff-coloured sand was exposed, interstratified with thin irregular brown ferruginous sandy bands.

Repps.—A large sand pit occurs a quarter of a mile E. of Repps Church, the sand which is of a white and buff colour, in places is interstratified with a little brown loam, and much contorted. I observed a few fragments of shells in the sand.

Clippesby.—A small sand pit is situated nearly a quarter of a mile S. of Clippesby Church, on the W. side of the road. The section showed brown and buff-coloured sand from 4 to 5 feet in thickness, irregularly overlying obliquely bedded buff-coloured sand, at least 7 feet thick, containing numerous fragments of shells, also a little white sand with black streaks of carbonaceous matter in it. Some indurated sand occurred in the lower part of the pit, and a little chalky Boulder Clay overlaid the sand in the higher part adjoining the road. Of the fragments of shells observed—which presented a waterworn appearance—the following species were identified:—*Turritella terebra,*† *Pholas crispata,*† *Tellina Balthica, Cyprina Islandica, Cardium edule, Mya arenaria, Mactra.*

A larger sand pit occurs a short distance to the S.E. of the above pit, a little further down the road on the E. side. This sand was of a buff-colour and overlaid by chalky Boulder Clay, but no fragments of shells were observed in the section exposed.

Billockby.—A large sand pit adjoining Billockby churchyard at the S.E. corner, when visited by me was very much overgrown and no good section was to be seen. The sand was of a buff-colour and contained fragments of shells; and traces of chalky Boulder Clay—which latter caps the summit of the hill—were observed in the upper part of the pit.

J. H. BLAKE.

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* Journ. Roy. Agric. Soc., vol. vi., p 577.

† These species are given on the authority of Mr. F. W. Harmer.—H. B. W.

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At this locality Messrs. Wood and Harmer identified a large number of species from the fragmentary shells, which occurred under similar conditions to those discovered many years previously at Caister and other places near Yarmouth, and which have generally been regarded as re-deposited Crag shells. The list, which is as follows, is chiefly taken from the "Supplement to the Crag Mollusca": but Mr. Harmer has kindly looked through it, and made some additions and corrections :—

LIST OF MOLLUSCA FROM THE "MIDDLE GLACIAL" SANDS AT BILLOCKBY, collected by Messrs. WOOD and HARMER.

Buccinum undatum, *Linn.*, *var.* tenerum, *Sby.*
Capulus Ungaricus, *Linn.*
Cerithiopsis tubercularis, *Mont.*
Chemnitzia internodula, *S. Wood.*
Cypræa Europæa, *Mont.*
× Dentalium dentalis, *Linn.* (Cor. and Red Crag, Living).
Litorina litorea, *Linn.*
——— rudis ?, *Maton.*
Nassa Cuvieri (pusio), *Payr.*
× ——— granulata, *J. Sby.* (Cor. and Red Crag).
——— incrassata, *Müll.*
Natica Alderi, *Forbes.*
——— catena, *Da Costa.*
——— clausa, *Brod.* and *Sby.*
Odostomia conoidea ? *Broc.*
× ——— unidentata ? *Mont.* (Red Crag, Living).
× Pleurotoma assimilis, *S. Wood* (Red Crag).
——— Dowsoni, *S. Wood.*
——— linearis, *Mont.*
Purpura lapillus, *var.* incrassata, *Sby.*
——— lapillus, *Linn.*
Rissoa curticostata (semicostata), *S. Wood.*
Scalaria Trevelyana, *Leach.*
Trophon antiquus, *Linn.*
——— ——— *var.* contrarius ?
× ——— ? Billockbiensis, *S. Wood*, n.sp.
× ——— mediglacialis, *S. Wood*, n.sp.
× ——— muricatus, *Mont.* (Red Crag, Living).
——— scalariformis, *Gould.*
Turritella incrassata, *J. Sby.*
——— terebra, *Linn.*
Anomia ephippium, *Linn.*
Astarte compressa, *Mont.*
——— Omalii, *De la Jonk.*
Cardium edule, *Linn.*
Corbula striata, *Walker* and *Boys.*
Cyprina Islandica, *Linn.*
Leda oblongoides, *S. Wood.*
× Limopsis pygmæa, *Phil.* (Cor. and Red Crag, Living).
Lucina borealis, *Linn.*
Mactra ovalis, *J. Sby.*
Mytilus edulis, *Linn.*
Mya arenaria, *Linn.*
Nucula Cobboldiæ, *J. Sby.*
Pecten opercularis, *Linn.*
Pectunculus glycimeris, *Linn.*
Scrobicularia plana, *Da Costa.*
Saxicava arctica, *Linn.*
× Tapes pullastra ? *W. Wood* (Red Crag, Living).
——— virgineus (?) *Linn.*
Tellina Balthica, *Linn.*
——— crassa, *Gmel.*
——— lata, *Gmel.*
——— obliqua, *G. Sby.*
Venus fasciata, *Da Costa.*
——— ovata, *Pennant.*

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Messrs. Wood and Harmer are, however, of opinion that the species were contemporaneous and not derived from the Crag, but at the same time they had an origin which was distant from the place of their occurrence, and had, most of them, been greatly worn during their transport to it by currents along the bottom. With the exception of the species marked × all the fossils from Billockby belong to species found in the Norwich Crag, and with the exception of *Venus fluctuosa*, *Loripes lactea*, and the new species, all the fossils found elsewhere in these glacial sands belong to Crag species. It is nevertheless remarkable, as pointed out by Messrs. Wood and Harmer, that not a trace or fragment of most of the common strong shells of the Coralline and Red Crags has occurred. Some of the delicate shells found in this glacial deposit they thought must have been brought by floating bodies such as seaweed.*

Hellesdon.—Several pits have been opened by Shepherd's Cottage, in the brickearth. In the pit adjoining the high road, 16 feet of very sandy brickearth was dug. It contained a few patches of flint-gravel, and contorted nests of buff sand. Buff carbonaceous sand has been exposed at the base to a depth of 2 feet.

Further east a pit showed the following beds:—

	Feet.
6. Sandy brickearth with few stones	4 to 5
5. Irregular patch of yellow and brown sand	2 to 3
4. Vein of stiff brown clay.	
3. Sandy clay with few stones	5
2. Line of sand and gravel with flint and quartz stones.	
1. Reddish-brown or chocolate-coloured stony clay, with pebbles, and fragments of flint	6 or 7

In the pit were occasional small boulders of flint, greenstone, veined quartz, brown quartzite, and granite (much decomposed).

North-east of Shepherd's Cottage, 15 feet of stony loam with contorted nests of sand has been dug. A patch of chalky clay was visible in this brickearth, having the appearance of an isolated unweathered fragment of the chalky Boulder Clay.

At the Asylum, 5 feet of stony brickearth containing a tiny patch of material like chalky Boulder Clay was opened up. (*See* Note, p. 98.) Veins of chalky clay also occur in the pit by Fir House.

Catton.—6 to 8 feet of stony loam has been opened up in the grounds of Catton Hall.

In Attoe's Pit a pocket of stony loam occurred at the north end of the pit, which cutting through the pebbly gravels (Crag series), rested in one place immediately on the Chalk.

Sprowston.—The brickearth has been most extensively worked on the southern borders of Mousehold Heath, and indeed all along the south-eastern portion of the parish of Sprowston. This brickearth is known as the Norwich brickearth, and the bricks as "Mussel bricks."

In the Norwich Museum is a small fragment of the tusk of *Monodon monoceros* from the brickearth of Sprowston.

The numerous sections have well displayed the lower Glacial beds, but are seldom excavated so as to expose the Crag series beneath; indeed only one instance of this has come under my notice, and that was in the pit about 1½ miles from the city gates on the Crostwick road.

The general succession of beds exposed in this neighbourhood is as follows:—

	Feet.
Coarse gravel. (*See* p. 130.)	5
Stratified sand and gravel	15
Stony loam, with nests of sand and gravel, often much contorted, containing pebbles of flint and chalk, occasional boulders, and becoming more chalky at the base. Total thickness observed	15

* *See* Supplement to Crag Mollusca, p. xxiii., and Quart. Journ. Geol. Soc., vol. xxxvi., p. 484. Lists from the other localities will be given in the Memoir on the country around Yarmouth and Lowestoft, in preparation by Mr. Blake.

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Three or four large pits, which in time will very likely become one, have been opened in the brow of the hill north and south of where the letter *M* of Mousehold Heath is engraved on the map. Commencing at the north section, No. 1 showed the following beds:—

	Feet.
Coarse gravel, resting irregularly on bed below	4 or 5
Fine stratified gravel and buff sand	7 or 8
Clayey seam.	
Stratified and false-bedded buff sands, with fine gravelly seam at base	8 or 9
Brown stony loam with scattered stones, 12 feet, passing downwards into blue and brown chalky clay, 5 feet, with ice-scratched flints and chalk	17

In this stony loam occur numerous fragments of shells. These were first noticed by Mr. J. E. Taylor as re-deposited Crag in the "Upper Brickearth" near Magdalen Chapel.* He detected them in a vein 2 inches thick, but they occur not only in the sandy nests but throughout the mass of the brick-earth. They are as follows:—

Cardium edule. *Mya.*
Cyprina Islandica. *Tellina.*
Mactra.

Section No. 2 showed:—

	Feet.
Gravel and sand; the gravel coarser at top	12 to 15
Clayey sand or sandy brickearth	3 or 4
False-bedded buff sand	6 to 9
Brickearth	7
Chocolate coloured stony loam	3 or 4

Section No. 3 showed:—

False-bedded sands with loamy seams	15
Stony loam with shell fragments	10

I am rather doubtful whether the sands in these sections should more properly be classed with the coarse gravels, or with the brickearth; the following section shows cause for uncertainty.

In the brickyard by Home Cottage the upper beds consist of stratified sands and fine gravel, capped by a foot of much coarser gravel. This deposit rests on a stony loam, which is truly a contorted drift. The contortions are very plainly cut off by the superincumbent gravels and sands, showing some unconformity between the divisions *a* and *b* in the section, fig. 18, Plate VI. Fragments of shells occurred in the sandy pockets. The section, which I noted in March, 1878, is drawn to a scale of about 15 yards to 1 inch, and is as follows:—

	Feet.
b. Stratified gravel and sand, in places much false-bedded	10 to 15
a. Stony loam containing pockets and contorted nests of buff sand, with carbonaceous specks. The loam passes downwards into a bluish-grey chalky clay, and attains a thickness of 30 feet (base not seen).	

Judging from the relations of the beds, I am disposed to group those marked *a* as Lower Glacial, and those marked *b* as Upper Glacial. (*See* p. 91.)

* Trans. Manchester Geol. Soc., vol. v., p. 44. The so-called Chillesford Clay of the Crag series he then grouped as "Lower Brickearth."

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At Gunnell's brick and tile works,* the following beds have been opened up:—

	Feet.
Brickearth	8
False-bedded sands with gravelly seam	3–4

A well here was sunk 70 or 80 feet into chalk.

North-east of Gunnell's brickyard, on the other side of the road, a pit showed (April 1877) the brickearth to be contorted with a nest of sand. About 12 feet of the beds were exposed. The base of the sand was not seen. A well here was sunk about 80 feet deep, through the Drift and Upper Crag into the Chalk.

At the brick-kiln south of Catton Lodge a deep cutting in the middle of the pit showed beneath the brickearth:—

		Feet.
Crag Series	Buff false-bedded pebbly sand	3 to 5
	Yellow and brown mealy sand	4 to 5

At the southern end of the pit 5 or 6 feet of false-bedded sand was shown beneath the brickearth, which might (?) be connected with the sand exposed in the middle of the pit. This was apparently forced up with the contorted drift if it was not included in it.

Norwich.—In the city itself the boundary of the Crag and Glacial deposits must to a large extent be drawn by the feature. Nevertheless I saw several foundation-pits and other excavations which served as important guides.

Behind the Primitive Methodist Chapel in the Queen's Road a pit showed 8 feet of brickearth. The railway cutting near Peafield showed false-bedded sand and gravel with a hard chalky layer. In digging the foundation for the new hospital 15 feet of buff sand was exposed. Sand and gravel were dug in foundations for houses along the New Road, Town Close; and in Mile End Lane, 10 feet of sand was opened up between Christ Church, Eaton, and the Newmarket Road. Further on by the Unthanks Road, near Christ Church, there are indications of brickearth, which I was at one time disposed to connect with the brickearth near Victoria Station; but Mr. Harmer informed me that during the drainage operations the openings in Mount Pleasant Lane were entirely in sand and gravel. Had the brickearth been persistent it would have been proved along this line. (*See* p. 4.)

Here and there traces of brickearth may be inferred from the nature of the ground, as north of Earlham Upper Farm, and half a mile north of Bowthorpe Hall.

Again brickearth was worked in a pit on the lane (just beyond the 2nd mile stone from Norwich) which leads from the Norwich and Dereham Road to Costessey Village.

Lakenham.—In the Brickyard on Long John's Road, the pit to the west of the road showed:—

	Feet.
Gravel and sand, well stratified in places, with pebbly and subangular stones, seams of yellow sand and white false-bedded sand. The upper part mostly gravel; the lower mostly sand, resting with irregular line on the bed beneath	20 to 25
Seam of fine laminated brickearth.	
Stony loam with pellets of chalk, unworn flints, and seams of yellow sand, base not seen	15

The loam here passed from a sandy loam to a chalky loam, resembling varieties of the chalky Boulder clay.

Thorpe.—A pit on the Plumstead Road above Spitalfields showed gravel and sand resting on brickearth with broken shells.

In the sands there occurred a loamy bed that became hard on exposure, something like the indurated beds at Mackie's nursery. (*See* p. 120.)

The brickearth was again exposed in the hill side south-east of Mousehold House.

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* Red bricks are manufactured here; and sometimes white bricks, when the clay is brought from Drayton and other places.

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Its extension east of Grove House is indefinite. It was well exposed in a pit just north of the Spinny, and again in a brickyard further north.

The latter section showed:—

		Feet.
Glacial Drift	False-bedded brown and yellow sands	5
	Laminated clay and sand	5
	Bluish-grey and brown loam	10
	Pale grey sandy clay and stiff clay, bottom not reached	

The pit north of the Spinny, near Thorpe lime-kiln, showed (April 1876) a fine section of false-bedded sand and gravel resting upon stony loam with nests and contorted seams of sand, and fragments of shells.

The section at Bishop's Bridge, Thorpe Hamlet, is shown in Fig. 3, Plate II., and described on pp. 5 and 73.

Rackheath.—In the wood north of Hall farm, a pit showed 10 feet of brown and yellow sand with gravelly pipes.

South of Salhouse Station the cutting in the railway showed loamy gravel resting on about 8 feet of sand.

Salhouse.—South-east of Bear's Grove a pit showed 10 feet of brown and white sand, with pebbly soil on top.

In a brickyard formerly opened between Lower Street and Plumstead Street, only a foot or two of sandy clay was met with, and much of the material used was brought from the pit in Little Plumstead.

Little Plumstead.—The large brickyard in Plumstead Street showed a long face of variable brickearth capped by stratified sands and gravels in apparent conformity:—

		Feet.
Glacial Drift	Gravel	5 to 6
	False-bedded yellow sands	4 to 8
	Very sandy brickearth	1
	Brown brickearth and stiff brown clay, in places laminated, underlaid, and further north abruptly replaced, by white earth	10 to 12
Upper Crag	Sand	1
	Vein of loam.*	
	"Cockles."*	

To the south and south-east the brickearth becomes attenuated and very sandy.

Good brickearth was however formerly dug in a field north-east of Plumstead Hall (Little Plumstead),† and used in making bricks for building the house.

North of the brick-kiln, Plumstead Street, are outliers of irregular buff sand and gravel, 5 or 6 feet in thickness.

A marl pit marked on the Ordnance Map, near Heath Farm, Sprowston, may perhaps have referred to some chalky mass worked in the Contorted drift.

Hamlington.—The brick-kiln ¼ mile west of the church showed 6 or 7 feet of stony brickearth.

The following section was observed in a pit to the south-east of the church, a quarter of a mile north of Burlingham House (Fig. 13, Plate IV.):—

D. Gravelly soil, 6 inches to 1 foot 6 inches.
C. Chalky boulder clay, 6 inches to 1 foot.
B. Buff false-bedded sand.
A. Brickearth.

The greatest thickness of beds visible was about 12 feet. The section is of much interest in showing the extremely irregular way in which the various beds of Glacial Drift occur. It may be compared with the section at Upton, *see* Fig. 14, Plate IV.

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* On the faith of the workmen.

† Two residences are marked as Plumstead Hall on the Ordnance Survey Map, one in Little Plumstead and the other in Blofield Parish.

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Blofield.—In a pit about ½ mile south of *Co* of Hamlington Corner (on the map) there was to be seen about 10 feet of stony loam with a trace of chalky loam like Boulder Clay, and containing chalk stones.

In this neighbourhood, and at Hamlington and Burlingham, it is exceedingly difficult to draw any boundary-line between the brickearth (Lower Glacial) and the chalky Boulder Clay, from the fact that the surface indications of both beds are very similar in character. (*See* p. 119.)

North-east of Plumstead Hall (Blofield) 10 or 12 feet of contorted sand and loam with nests of buff sand was visible.

South Walsham.—A pit S.W. of Walsham Farm, on the road leading towards Green Lane Plantation, showed from 15 to 18 feet of Contorted brickearth and sand, with traces of chalky Boulder Clay on lower ground at the northern part of the pit.

Upton.—North-west of the church a pit showed the following beds (1878) which are represented in fig. 14, Plate IV.:—

	Feet.
3. Chalky Boulder Clay - -	3
2. Sand.	
1. Stony Loam with nests of sand -	14

This is one of the few sections where the triple succession of the so-called Upper, Middle, and Lower Glacial Beds of Norfolk can be seen in one section: but even here the sand is absent in one part of the pit. This section has been mentioned on several occasions by Messrs. Wood and Harmer in their writings on the Drift. It is illustrated in section O, attached to their map of the Crag District, published by the *Palæontographical Society*.

Lingwood.—West of the Poor House the following section was exposed:—

		Feet.
Glacial Drift	Brown stony loam - - -	5 to 8
	Buff false-bedded sand - - -	9

I have been much puzzled to say whether this stony loam is a weathered variety of the chalky Boulder Clay, or if it should be classed as of Lower Glacial age. Judging from the general characters and position of the Boulder Clay in this neighbourhood it might be classed with it. At the same time the Lower Glacial stony loam is opened up east of Bradeston Church, and it approximates closely to the character of that: the buff false-bedded sand is, however, much like that often found underlying the chalky Boulder Clay, and if this prove to be the same, then the Boulder Clay of Strumpshaw must be united with that at Lingwood.

The following notes are by Mr. Blake:—

Hasingham.—Nearly a quarter of a mile N.N.E. of the church, on the west side of the road, close to Hasingham Farm, a pit occurs, where loam has been excavated and put on the marshes to form a road. A good section showing from 12 to 15 feet in thickness of very stony reddish-brown unstratified loam was exposed, overlying 1 foot 6 inches of well-stratified brown loam and sand, and this latter overlaid 2 feet of ash-coloured sand with some black specks in it. This was the whole of the section shown. Numerous fragments of shells were evenly scattered throughout the mass of stony loam, the pebbles in which mostly consisted of flint and quartz. I observed a flint boulder about 1 foot in diameter in the middle of the stony loam.

Acle.—An old loam-pit occurs a little more than a quarter of a mile S.S.E. of the church on the south side of Damgate Lane. A considerable quantity of loam has been excavated here; the pit was mostly grown over when visited by me, but a good section was exposed in the south-west corner, showing 12 feet in thickness of reddish-brown stony loam, overlaid by about 1 foot of chalky Boulder Clay.

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A small pit is situated a few yards to the east of the above, where a good section showing 12 feet in thickness of very stony unstratified brown loam was exposed.

In a small excavation made in order to procure some sand, in a field situated about three-eighths of a mile N.E. of the church, on the north side of the road, and about 200 yards to the west of "the Hermitage Inn," about 6 feet or more of reddish-brown stony loam was exposed, overlying some buff-coloured sand, which latter may possibly have been a patch of sand in the loam, not an uncommon occurrence.

Two old loam-pits occur close to the mill N.W. of the church, south of the lane, one to the east, the other to the west of the mill. I was informed that a considerable quantity of sand had been taken out of the pit to the east of the mill. This was very possibly a patch in the loam. There was also a little buff-coloured sand in places overlying the loam.

Fishley.—An old sand-pit occurs adjoining the churchyard on the west side. The sand was of a buff-colour and apparently of considerable thickness, but no good section was exposed.

In a sand-pit, situated about 300 yards S.W. of Fishley Hall, on the west side of the road, about 8 feet in thickness of buff-coloured sand was exposed, underlying 1 foot of chalky Boulder Clay on the west side of the pit.

Tunstall.—A small sand-pit occurs a quarter of a mile E.N.E. of the church, on the south side of the road leading down to the marshes. About 8 feet in thickness of buff-coloured sand was exposed. Chalky Boulder Clay overlies this sand on the higher ground to the west, and loam is shown to underlie it, in a pit on the south side of the same road, about 100 yards further down to the east. Here about 9 feet in thickness of reddish-brown loam was exposed, which had been excavated for the manufacture of red bricks.

Halvergate.—A sand-pit occurs on the west side of the road, nearly three-quarters of a mile S. by W. of the church. From 7 to 8 feet of buff-coloured sand was exposed, the upper part of which was interstratified with reddish-brown loamy sand, more or less indurated. On the north side of the pit about 1 foot in thickness of chalky Boulder Clay overlaid the sand.

A large quantity of sand has been excavated from a pit situated 200 yards N.E. of the church. The sand, of considerable thickness, was overlaid by chalky Boulder Clay and underlaid by loam, but the pit is now much grown over and no good section is to be seen.

Moulton.—A sand-pit occurs three-eighths of a mile W.N.W. of the church, on the south side of the road. From 10 to 12 feet in thickness of stratified buff-coloured sand was exposed, containing a few bands of brown loam. The sand rested on loam, and was overlaid on the south side of the pit, by about 3 feet in thickness of brown loam containing coarse flints, &c.—the tailing-off of the chalky Boulder Clay which occurs on the higher ground immediately to the south of the pit.

Another sand-pit of a large size is situated five-eighths of a mile S.W. by W. of the church. The pit is now much overgrown with bracken, but 18 feet or more in thickness of stratified buff-coloured sand was exposed, overlying reddish-brown loam, 3 feet of which latter was shown in an excavation at the bottom of the pit.

A small brickyard occurs a little more than half a mile N.N.W. of Moulton Church. About 6 feet of unstratified brown loam was exposed in an excavation, which had been partially filled in when visited by me.

Southwood.—Brown loam and loamy clay is exposed on the sides of numerous ponds, ditches, road-cuttings, and other excavations in the neighbourhood of Southwood Hall. An old man, who had worked 60 years on the Hall Farm, informed me that the whole of the land belonging to the farm consisted of loam; and the last time they clayed the fields was about 30 years ago, when the chalky Boulder Clay was fetched from the clay-pit situated to the west of the road, nearly half a mile S.S.E. of the church, there being no chalky clay on the farm.

Cantley.—The church is situated on buff-coloured sand, which was exposed recently in making excavations for alterations. Buff-coloured sand overlying loam also occurs to the N. of the church, as shown on the Geological Survey Map. A considerable thickness of it was shown in a pit—now mostly filled in—situated a quarter of a mile N.W. of the church.

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In the railway-cutting, a little more than a quarter of a mile S.W. of the church, on the east side of the road, about 7 feet or more of reddish-brown stony loam occurs overlying sand. At the time I visited the cutting, sand was exposed beneath the level of the sleepers.

About three-eighths of a mile to the west of the church, three small pits occur, now mostly filled in; in which I was informed sand and loam occurred, the loam occurring in the upper part. The material was excavated for making a road on the marshes.

On the sides of the road nearly half a mile W.N.W. of the church, I observed some orange-coloured and reddish-brown sand, overlaid by stony brown loam.

Limpenhoe.—A clay and marl pit occurs in a field situated a little more than three-eighths of a mile S.E. by S. of the church. The pit has been excavated to a depth of about 15 feet or more, but when visited by me in 1879 it was much overgrown with grass, and the lower part of the section otherwise hid by talus, &c., only the upper part being clearly exposed in a few places. At the west end of the pit a little reddish-brown gravel overlaid a large patch of whitish marl, consisting apparently of re-deposited chalk, containing some large flints, which had a very fresh appearance, much resembling those recently extracted from the Chalk. At the eastern end of the pit, a little reddish-brown pebbly gravel — consisting mostly of flint and quartz — overlaid a patch of chalky Boulder Clay of a grey colour weathering a yellowish white, near to which was a considerable quantity of brown loam. The chalky Boulder Clay and marl had been excavated to put on the fields.

Freethorpe.—Half a mile S.W. by W. of Halvergate Church a clay and loam pit occurs in a field on the north side of the road. About 15 feet in thickness of stony brown unstratified loam was exposed, and from about 6 to 8 feet of chalky Boulder Clay, which latter appeared to lie in a hollow of the loam, on the east side of the pit; the top of the Boulder Clay and that of the loam being at the same level on the surface of the ground. The chalky Boulder Clay lies, with respect to the loam, in a very similar manner in a large pit at Upton. (*See* p. 100.)

In the north-east corner of the brickyard, situated one mile and a quarter N. of Reedham Railway Station, a considerable thickness of buff-coloured sand occurs, which however was much hid by talus when seen by me. A recent excavation, which did not show the maximum thickness of the sand, exhibits the following section, viz., 9 feet in thickness of buff-coloured sand with reddish-brown bands in it, underlaid by 4 feet of well-stratified brown loam with grey loam in places, and which was slightly contorted. This loam apparently is laminated in certain parts, and as it was excavated towards the south became 7 feet in thickness and contained a foot, or a little more, of sand interstratified. On the north side of this recent excavation the 4 feet of loam was underlaid by 2 feet of whitish sand, containing chalk grains and small pebbles of chalk; beneath this, stiff sandy loam, more or less contorted, occurred.

The maximum thickness of brickearth exposed on the south side of the brickyard is about 22 feet, which is overlaid by chalky Boulder Clay and underlaid by sand. The upper part of the brickearth for about 6 feet in thickness is more or less stratified, and is of a light grey colour with brown loam intermixed; the middle part, for about 10 feet in thickness, is unstratified and of a blackish-grey colour, weathering a yellowish-white; and the lower part, 6 feet in thickness, is finely laminated, with thin ferruginous seams in places, and of a light brown, grey, and whitish colour, mostly consisting of loam and clay. Four feet in thickness, at least, of the lowermost portion of the middle part, consisting of unstratified blackish-grey brickearth, is shown to change laterally, within a distance of 50 feet, into well stratified brown and grey brickearth; and the stratified portions above and below pass up and down imperceptibly into the unstratified blackish-grey brickearth. A few yards further to the west the unstratified brickearth apparently increases in thickness, merely having a few impersistent thin seams of brown sand in the upper part, together with a few marly patches and seams. The beds undulate considerably in places, and in one part were shown to be contorted, producing a hummock for a few feet in length. The brickearth mostly consists of a blackish-grey

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stiff loamy clay, which, when burnt, produces bricks of a yellowish-white colour. It is very similar in character to the brickearth at Woolpit, near Bury St. Edmunds, in Suffolk, which place, it is stated, has been noted for its white bricks since the time of Queen Elizabeth. (*See* p. 110.)

The sand underlying the laminated brickearth is of a buff and white colour, and contains numerous fragments of shells, together with lenticular patches of pebbly gravel, mostly consisting of flint and chalk, which latter pebbles are covered with dendritic markings.

In the south-west corner of the wood, adjoining and south of the above brickyard, brickearth has been excavated, and showed a section exhibiting 9 feet in thickness of very finely stratified brown, yellowish, and greyish loam and clay, gently undulating. These beds are evidently a continuation of those in the brickyard previously described, and are only a few yards distant from them. The greyish loamy clay of a certain band weathers a whitish colour and breaks up into conchoidal pieces. The loam in places presents almost a laminated appearance, the stratification being so very fine.

Reedham.—Brown loam, of which I saw a section showing about 6 feet in thickness, has been excavated in a pit on Reedham Hills, situated three-eighths of a mile S.E. by E. of the railway station. The loam overlies pebbly sands, and the latter, Chillesford clay, as shown in the brickyard a short distance to the north of this spot, near the railway bridge.

From 4 to 5 feet in thickness of brown loam is exposed on the side of the pond to the east of Reedham Hall, situated a little more than half a mile N. of the church. The loam appears to lie very thin on the high ground in the neighbourhood of the hall, underlying this is reddish-brown gravel and sand, which is exposed in places on the sides of the road leading down to the marshes to the east of the Hall.

Brown loam was exposed in a small pit, a little more than half a mile N.W. by N. of the railway station, south of the road, and a short distance N. of John's Car.

Close to the railway bridge, across the river Yare, on the N. side, buff-coloured sand several feet in thickness occurs, overlying the gravel and s with some loam intervening.

J. H. Blake.

2. *Area between the Yare and the Waveney.*

The brickearth, which forms so conspicuous a feature in the district north of the Yare, and indeed covers a large portion of the country northwards as far as the Cromer cliffs, is conspicuous rather by its rare occurrence when we glance at the geological map of the area south of the Yare. So little brickearth is met with that for a long time I could not settle in my mind whether or not the chalky Boulder Clay was distinct from the stony loam. The absence or rarity of this formation where the Lower Glacial brickearth was well developed seemed to favour the notion. The apparent passage of stony loam into chalky loam at the brickyard in Long John's Road, also in the railway-cuttings north-west of Hapton, the difficulty in the parishes of Postwick, Brundall, and Plumstead of drawing a line between the chalky Boulder Clay and the stony loam, where the two seem from their physical relations to merge one into the other, tended to support the supposition that they were but one formation. (*See* p. 94.)

The pits at Upton, Hamlington, and South Walsham, however, serve to throw some light on this subject; there the succession of beds is shown as well as their uncertainty of development. As far south as Ditchingham, Mr. Reid has noted a threefold division; but this arrangement, as before mentioned, is exceptional.

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The most distinctive character appears to me to be in the fact that the chalky Boulder Clay is very irregular in the position of its occurrence, wrapping over other deposits and descending into the valleys here and there; but the Stony loam or Contorted drift does not occupy such different levels.

In this area the chalky Boulder Clay over a large area rests directly upon the Norwich Crag. In many places, however, there intervene buff sands which seem to belong to the Glacial period, although it is not possible to demonstrate such to be the case.

From Trowse Newton southwards to Arminghall and Stoke Holy Cross there is considerable difficulty in drawing a definite line between the Glacial sands and the Norwich Crag.

Trowse.—*See* p. 124.

Stoke Holy Cross.—Near the entrance to the park of Henry Birkbeck, Esq., north of Stoke Holy Cross Church, there is a concretionary mass of sandstone 9 feet across, having an irregular weathered outline, and presenting a remarkable feature in a country where rock is as a rule unknown. (*See* p. 93.)

A section of the sands may be seen about half way between the church and the mill. (*See* p. 71.)

In the churchyard, as I was informed by the Rev. J. Bailey, the graves are dug through sand, then a vein of brickearth, and afterwards into silver sand, for 6 feet. By the windmill, near the Rummer Inn, 6 feet of sand was shown.

Keswick.—About half a mile south of the ruined church a large gravel pit showed the following section :—

		Feet.
Glacial Drift	Brown false-bedded sand and fine gravel	15 to 20
	Contorted loam and sand passing into	2
	Brown brickearth	6 ins. to 1
Upper Crag ?	False-bedded chalky sand and pebble gravel with large boulders of flint, quartz, and quartzite, and flint pebbles	12 to 14

Markshall.—The deep cutting on the Great Eastern Railway at Chapel Hill showed a great thickness of sand and gravel with traces of Boulder Clay and brickearth. (*See* p. 72.)

A small pit opened at the N.W. corner of the Barn showed 3 feet of buff sand.

In 1822 an account was given by Charles Layton of the remains of a Roman kiln or furnace for making pottery, which was discovered upon a hill about a quarter of a mile north-west of the camp at Caistor. He remarked that "The "bottom of the kiln, of an oval form, rested upon a natural bed of soft "yellow sand."* It seems probable that the Boulder Clay was used for the pottery, &c.

Ashwell Thorpe.—A cutting on the new line of railway showed a mass of chalky Boulder Clay weathering in its horizontal extension into a brown loam, undistinguishable in character from the Stony loam. (*See* p. 123.)

The section (*see* Fig. 22, Plate VII.), showed—

d. Gravelly soil.

b. Chalky Boulder Clay, passing into—*c.* Brown clay or stony loam.

a. Grey and yellow sands and pebble gravel in places contorted. (Upper Crag.)

Shottesham.—The large pit by Sheets Hill, like the deep cutting at Chapel Hill, Markshall, exhibits a mass of gravel embracing two if not three distinct deposits.

Archæologia, vol. xxii., p. 412.

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The upper portion appears to represent the coarse gravel of Mousehold, the middle portion the so-called Middle Glacial, and the lower the Crag series. In the middle portion Mr. Whitaker detected fragments of shells, among which *Cardium edule* alone was recognizable. Mr. J. E. Taylor also obtained a species of *Mactra*. "A mile further, on the road to Saxlingham, another section was "described (by Mr. Taylor) composed of brickearth and 'till,' also yielding "shells. The third section, 1½ mile distant, also brickearth, some 10 or 15 "feet in thickness contained immense quantities of fragments of shells, "and even some entire examples. *Mya arenaria, Cyprina Islandica, Tellina* "*Balthica* (*solidula*), *Mactra subtruncata, Cardium edule, Turritella terebra* "(*communis*) were among the shells identified, besides numerous doubtful "species."* (*See* p. 113.)

Howe.—About a quarter of a mile N.E. of the church a pit was opened in stony loam.

Burgh Apton.—A pit by the church showed 6 to 8 feet of gravel and buff sand. The age of this is doubtful. Perhaps it may be Pliocene, but on the other hand it may be newer than the Boulder Clay.

Thurton.—About three-quarters of a mile east of the church, a brickyard showed brown clay with patches of chalky Boulder Clay resting on 5 feet of brown and yellow clay.

Langley.—The sand pit at Langley Street showed traces of purple and reddish-brown clay like Eocene near the base. The section showed 8 feet of sand and gravel with a patch of chalky Boulder Clay, resting on 10 feet of buff false-bedded sand.

N.E. of the church a section showed 6 feet of brown clay with patches of chalky Boulder Clay, resting on 15 feet of buff sand.

At High Grove a brickyard was opened, and 5 feet of sandy loam, probably weathered chalky Boulder Clay, was exposed.

Chedgrave.—S.W. of the Manor House 6 feet of stiff brown clay and stony loam, capped by sand, was opened up for brick making.

The large pit by Chedgrave Church was probably opened in pebbly gravel. Six feet of this was shown just south of the letter *h* of Chedgrave (on the map). (*See* p. 85.) Sand and gravel occur on Chedgrave Common.

Hardley.—West of Lives Heath 8 feet of sand was shown. To the north, by the cross roads, a pit showed 15 feet of sandy and stony loam, with nests of sand and gravel. S.W. of the Hall is a pit showing nearly 20 feet of coarse pebbly gravel, containing large rounded flints, some unworn flints, a few pebbles of quartz and quartzite. To the east of the Hall, these beds are underlaid by brickearth.

Mundham St. Peter.—North of Thwaite Spring, Mr. Reid observed false-bedded chalky and rather carbonaceous sand beneath the chalky Boulder Clay. In one place it was shown to have a thickness of 18 feet.

The following notes are by Mr. Reid:—

Loddon.—At the brickyard S. of the town the following beds were exposed:—

	Feet.
Buff sand, pebbly at base	2
Unstratified or obscurely bedded stony and sandy brickearth, with shell-fragments and a few streaks of marl	11
Small gravel	4+

At the sand-pit N.W. of Loddon Hall I observed the following beds:—

Glacial sand.	Feet.
Bedded brickearth, with scattered pebbles of flint, quartz, chalk, and dark red sandstone, angular flints and fragments of *Cardium edule, Mya, Tellina, Cyprina Islandica*	4
Gravel of angular stones and pebbles	2

South-west of Loddon Hall are pits in fine white false-bedded sand.

C. Reid.

* Geol. Mag., vol. ii., p. 511. The hill is termed Skates Hill by mistake. In a little work entitled "Lithographs" (1866), Mr. Taylor recorded 18 species from the sand pit.

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Heckingham, Norton.—East of the church is a sand pit, and a little to the south a pit showed 12 feet of brown stony loam, with sandy capping.

Three-quarters of a mile E.S.E. of the church a large pit showed Boulder Clay resting on fine buff false-bedded sand and sandstone.

South of Hill House a pit showed 12 feet of pebble gravel, chiefly made up of flint; and south of Norton Hall another pit showed a similar thickness of pebble gravel with large flints, some ironstone nodules, with irregular capping (6 feet) of loam and sand, and traces of chalky Boulder Clay.

At Norton Street are two pits of pebble gravel and sand, in one of which 15 feet of the deposit was shown. In the garden of the House of Industry Mr. Reid observed a pit in fine white sand.

Thorpe (next Haddiscoe).—A pit by Thorpe Hall showed about 10 feet of pebble gravel or shingle, composed of quartz and flint, false-bedded with sand, resting on about 16 feet of buff false-bedded sand. (*See* p. 85.)*

The following notes are by Mr. Reid :—

Hales.—Half a mile N.E. of Loddon Hall a pit showed re-constructed Chalk, resting on coarse unworn flint-gravel, and sand, and this upon stony loam. All were contorted together.

South-west of the House of Industry a pit showed sandy and stony loam resting on fine yellowish false-bedded sand, with carbonaceous grains. An irregular mass of gravel rested on them.

Further south a pit exposed fine and coarse gravel, partly consolidated into large blocks of breccia. The stones were principally flints, with some small quartz pebbles. The coarser gravel contained a large quantity of Lincoln Oolite (?) pebbles, probably 20 per cent. East of Hales Green a sand pit showed fine white sand, with many small scattered chalk pebbles, altogether about 10 feet in thickness.

At the S.E. corner of the Green the following section was to be seen :—

	Feet.
Brown loamy soil, descending into pipes in the Boulder Clay	2
Boulder Clay, weathering white	6
resting with a sharp uneven line on	
Fine white sand, minutely false-bedded, and containing carbonaceous grains	4

S.W. of Hales brickyard a pit showed chalk gravel resting on Lower Boulder Clay, very irregular and contorted together. The chalky Boulder Clay appeared just above.

The brickyard 1 mile N. of Hales Church showed brown brickearth with scattered pebbles and angular flints 5 feet in thickness. In one part of the pit sandy gravel came on above. (*See* p. 126.)

Raveningham.—S.W. of Crossway Farm a pit showed chalky Boulder Clay resting on fine white sand, much false-bedded and full of carbonaceous matter. North of Daws Wood is a pit showing about 10 feet of fine white well-bedded sand. North-east of Raveningham Cottage a similar section may be seen. Here the sand yielded fragments of *Cardium*. (*See* p. 126.)

Toft Monks.—A sand pit half a mile N.E. of the Hall showed the following section :—

	Feet.
Soil	1 to 3
Boulder Clay	5
passing into	
Sandy bedded loam with scattered stones	5
Very fine white false-bedded sand, with carbonaceous grains	5

North of the church 10 feet of fine white false-bedded sand was to be seen.

Gillingham.—In pits north of the church and west of Hobbs Hill Wood, Boulder Clay may be seen resting on white false-bedded sand with carbonaceous grains. A pit west of the church showed laminated brickearth with seams of chalk pebbles, and a few unworn flints, resting on fine sand. (*See* p. 126.)

* *See* F. W. Harmer, Geol. Mag., vol. vi., p. 234.

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N.W. of Winston Hall a pit showed the following beds:—

	Feet.
Soil	1½
Boulder Clay	2 or 3
passing down into	
Bedded brickearth with chalk pebbles	3
Sand?	

Stockton.—A quarter of a mile south of the church a pit showed whitish brickearth with unworn and worn flints, chalk, &c., 10 feet, resting on fine sand, 5 feet. About a furlong E. of the church was exposed 17 feet of sand, with capping of loamy soil.

Kirby Cane.—At the Parsonage a pit showed very fine white sand, 5 feet in thickness, with a little chalky Boulder Clay on the top.

At Leek Hill and Wood are pits showing 25 to 30 feet of sand, with beds of gravel. South of the Green is a pit showing 6 feet of fine white sand, the upper part hardened.

Ellingham.—South-east of Dulls House a pit showed false-bedded sand, gravel, and brickearth, very irregularly disposed.

Broome.—At the brick-kiln three-quarters of a mile east of the church, the section showed bedded marl, the upper part with race, brickearth, and sand, with beds and pockets of gravel; about 12 feet in thickness.

Hedenham.—A sandpit near Hedenham brickyard showed, at the east end of the pit, 8 feet of coarse ferruginous valley gravel.

Near the road the following section was observed:—

	Feet.
Loamy soil (which has been used for bricks)	1 or 2
Coarse valley gravel	4
Stony loam, like Lower Boulder Clay, but without shells (possibly an old alluvium, but it is clearly underneath the valley gravel)	0 to 2½
Greenish grey pebbly sands; more than half the pebbles are foreign, consisting of quartz and flints, with a large number of quartzites	5+

Woodton.—A pit a quarter of a mile S.W. of Woodton Hall showed the following sections:—

		Feet.
E. end of pit	Soil, sandy loam with a few stones	4
	Fine evenly-bedded sand	6
	Thin bedded loamy brickearth	2
W. end of pit	Soil and sand as above (not clear)	6
	Laminated marly brickearth, with small chalk pebbles	8½
	Fine white chalky sand, much false bedded	3+
Middle of pit (lower level).	Fine white sand and seams of chalk gravel, containing occasional shell-fragments	3+

The Upper Boulder Clay comes on within a few yards of this pit, and is not more than 2 or 3 feet higher than the top of the section.

A quarter of a mile E. of the church a pit showed:—

	Feet.
Fine sand	8 or 10
Gravel with worn and unworn flints, a few foreign pebbles, rolled pieces of chalk, grey clay and lignite, and indeterminable shell-fragments	6+

The pit was much overgrown, but showed no trace of brickearth.

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N. of the meeting-house, a pit exposed the following section :—

		Feet.
	Gravel soil, very irregular - - -	2 or 3
Glacial Drift -	Chalky Boulder Clay - - - about	2
	Very irregular mixture of nests of chalk gravel, sandy angular flint gravel, and large unworn flints - - - - -	6
Upper Crag -	White pebble gravel, with much quartz (Bure Valley Beds) - - - - -	2+

Ditchingham.—Under the *s* of Bath Hills (on the map) there is brickearth (Lower Boulder Clay?) with scattered stones, a few feet above the stream, apparently cutting into the Crag.

Ten chains S.W. of Cold Bath House, the following section was to be seen :—

	Feet.
Lower Boulder Clay, partly laminated; fragments of *Cardium* -	15?
Fine angular gravel, with fragments of *Cardium*, &c. - -	2+

A clay-pit on the Bath Hills showed Upper Boulder Clay, Glacial Sands, Lower Boulder Clay, and Pebbly Beds. The Lower Boulder Clay contained fragments of *Cardium edule, Cyprina Islandica, Tellina Balthica, Mya*, sp.

Half a mile S.W. of Cold Bath House a pit showed brickearth with scattered flint pebbles and chips, and slight traces of bedding, 7 feet; overlaid by about 10 feet of fine false-bedded sand, with fragments of coal and shell.

A quarter of a mile S.W. of Cold Bath House was exposed unstratified brickearth, with scattered stones, passing into laminated calcareous brickearth. The whole appeared to rest on pebble gravel.

Earsham.—A pit S. of Buckenhams showed chalky Boulder Clay resting on sand. Loose in the pit were boulders of angular flaggy sandstone, 2½ feet long, and portion of a striated septarian nodule, &c.

At Buckenhams clay-pit there was exposed false-bedded sand with a little gravel, containing chalk, pieces of lignite, and rarely fragments of shell. These beds were capped by about 6 feet of chalky Boulder Clay.

South of Earsham House a pit showed fine white false-bedded sand with coal grains, about 15 feet in thickness.

Denton.—Three furlongs S.E. of the church a pit showed the Lower Boulder Clay with shell fragments, as at the Bath Hills, capped by 3 or 4 feet of gravelly wash. A few yards above there is a pond in Upper Boulder Clay; the Glacial Sands must be absent, or not over 3 or 4 feet thick in thickness.

East of Denton House I observed sandy brickearth with scattered angular and rounded stones, no bedding, and about 15 feet in thickness, apparently resting on finely-bedded sand with pockets of chalk pebbles.

3. *Area South of the Waveney.*

Bungay.—N.E. of the Thatched House Inn a pit showed brickearth with scattered stones and chalk, and pipes of gravel.

A sand-pit above Thatched House Inn showed about 25 feet of sand, the upper part false-bedded and rather gravelly. The stones were covered with dendrites.

West of Stow Park Farm a sand pit showed very fine white false-bedded sand, capped by brownish sand, about 15 feet in thickness.

North-east of Duke's Farm a pit showed about 20 feet of very fine false-bedded sand with grains of coal (?); a few thin beds of flaggy sandstone occurred at the top.

Mettingham.—A pit S. of Boarded Barn Farm showed finely stratified sand, with much false bedding, 12 feet in thickness, with a bed of coal grains and some small pieces of chalk. At the top it was in places contorted, and capped by about 2 feet of laminated marl full of chalk, passing up into chalky Boulder Clay.

S.E. of the watch-house a pit showed fine white false-bedded sand with scattered pebbles and beds of gravel; also thin seams of carbonaceous parti-

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cles and rarely fragments of shells. This was capped irregularly by whitish drift of chalk and flints.

A pit S.W. of the church showed about 15 feet of fine false-bedded sand with a few small stones and grains of coal (or lignite).

A quarter of a mile S. of the Excise Office Ticket-bar a pit showed sand with occasional small shell-fragments.

Shipmeadow.—At the Hundred House of Industry a pit exposed false-bedded sand with grains of lignite and fragments of shells, *Cardium*, &c. (? derivative); 10 feet of flint and chalk-gravel, mostly well worn; 3 feet of sand, with coal-grains as below; and about 3 feet of Boulder Clay on top.

Another section showed gravel with seams of sand 25 or 30 feet in thickness. A little Boulder Clay occurred on the top in one place. The stones in the gravel were generally flint and chalk, and usually well rounded. *Gryphæa incurva*, *Belemnites*, and three species of Echinoderms in flint were found.

Nearly half a mile west of the House of Industry a pit showed 30 feet of fine false-bedded sand with coal grains.

A pit a quarter of a mile E. of "The Compasses" showed about 20 feet of fine sand, with a little fine gravel and rarely fragments of *Cardium*.

Barsham.—A brickyard south of Ashmans showed Boulder Clay with large boulders of chalk, &c., about 13 feet in thickness, resting on pebbly sand (Glacial), with the following species of Mollusca:—

Litorina litorea.	Lucina borcalis?
Purpura lapillus.	Mya arenaria.
Cardium edule.	Pecten opercularis?
Cyprina Islandica.	Tellina Balthica.
Leda sp.	

S. of John John's Wood, Barsham Hill, there was a pit in fine false-bedded sand and well worn gravel; some beds were very loamy. About 6 feet of the beds were exposed.

A gravel pit N. of Beccles School Farm showed about 15 feet of sandy gravel with seams of loam, unusually large pebbles, and occasional fragments of *Mya*, *Cardium*, &c. 3 or 4 feet of finer sand occurred at the base.

Ringsfield.—A *gravel pit* S.W. of the church showed about 30 feet of gravel with some sand, irregularly bedded.

About 12 feet of gravel and sand, mostly well worn and slightly false-bedded, was to be seen by the Hall.

A pit under the first i of Ringsfield (on the map) showed about 10 feet of pebbly sands. A pit at the Hall showed about 7 feet of pebbly sand, resting on 2 feet of sand.

Another pit a quarter of a mile S.E. of the church showed Boulder Clay, resting on pebbly sand about 20 feet in thickness (?).

Beccles.—North of Wash Lane Farm a pit showed in a mound left in the middle, chalky Boulder Clay, Glacial sand, and Lower Boulder Clay resting on pebbly beds. The height of the section was 20 feet.

At Rigbone Hill clay pit, the following section was exposed:—

	Feet.
Boulder clay	12
Fine sand, with fragments of *Mya*, *Cardium*, and *Leda* (in one place slightly contorted to a depth of about 10 feet)	about 25
Pebble gravel.	

Darby's brickyard on Rigbone Hill showed the following section:—

	Feet.
Chalky Boulder Clay	2½
Stony loam, with fragments of *Cardium edule*, *Cyprina Islandica*, and bones of *Sus* and *Ichthyosaurus*	12
Sand and gravel irregularly mixed with clay (contorted?)	8
Orange and white sand and gravel	5
Gravel	3
Sand	?

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At the Low Farm a pit showed 6 feet of chalky till apparently above fine sand. Another pit nearer the farm showed fine sand with seams of chalk pebbles resting on angular flint and chalk gravel.

N.E. of Ashmans the following section was shown:—

	ft.	in.
Loamy sand, with occasional scattered stones, and an inch seam of clay - - - - - about	10	0
Rough ferruginous gravel - - - - -	0	6
Buff loamy sand - - - - - -	6	0
	16	6

St. John Ilketsal.—Half a mile S. of the church a pit showed fine false-bedded yellowish sand with scattered stones and abundance of carbonaceous grains. E. of the church a section exposed about 20 feet of fine sand with carbonaceous grains and occasional fragments of *Cardium*. At the top there was a little very fine gravel.

Weston.—E. of the church a pit showed sand and subangular gravel in irregular beds. At the east end of Wash Lane there was exposed about 3 feet of moderately coarse subangular and pebble gravel.

CLEMENT REID.

C. Laminated Brickearth.

Resting upon the pebbly gravels and laminated clays of the Crag series in the parishes of Rockland and Surlingham; beds which are well shown in pits within a quarter of a mile westwards of the New Inn, Rockland St. Mary, and by Surlingham Wood; there are found in a line between Surlingham St. Saviour's Church, and Rockland Hall, a number of pits opened in blue clay and yellowish grey laminated brickearth, which are distinct in character from the clays of the Crag series, and from the Lower Glacial Brickearth or Stony loam. These beds are worked for the celebrated Rockland bricks, and clearly underlie chalky Boulder Clay.

For some time after seeing these beds I was in doubt about their equivalents in other parts of the country examined by me, and about their position in the geological scale, and from not having at first seen their base I thought it even possible that they might be of Eocene age.

During a visit to Brandon and Thetford, under the guidance of my colleague Mr. Skertchly in 1877, I was much struck with the similarity of the clays he there termed the "Brandon Beds," with the blue and grey brickearths of Rockland and Surlingham. On my return to Norwich I took the first opportunity of revisiting these sections, and was more than ever struck with their similarity. Having communicated these notions to Mr. Skertchly he came over and visited all the sections with me, and was equally struck with the many and striking resemblances exhibited.

In the present state of the evidence this correlation is only suggested: no palæolithic implements have been found in the beds at Surlingham* and Rockland.

* It may be well to note here that at Surlingham there is a distinct laminated brickearth (identified by some as "Chillesford Clay") developed in the Crag series, in which remains of Mastodon have been found. (*See* p. 88.)

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[I may, however, mention that since these notes were written Mr. S. V. Wood, jun., wrote to me (October 17, 1879) and inquired if any palæolithic implements had been found in these beds; and in a subsequent letter (October 21) he expressed his opinion that the brickearths might be coeval with the Hoxne bed yielding the implements.

This is the view that Mr. Skertchly had taken some time previously, and it is interesting to note such concordance in views independently arrived at. It is further of interest to quote Mr. Wood's latest expression of his views in the following paragraph: "The position of the Chalky Clay in this trough [Waveney-Ouse "Valley near Lopham Ford] applied to the phenomena disclosed "by the Yare Valley, clears up, it seems to me, all difficulty, and "proves that the Hoxne palæolithic brickearth, so well known to "geologists by the description of Prof. Prestwich, is of the age of "the Chalky Clay itself, though of the latest part of it."]*

It can only be conjectured that these deposits may belong to an interglacial period, but that they were laid down before the whole of the chalky Boulder Clay was spread over the area admits of no doubt.

As these beds may ultimately possess more than an economic value, should palæolithic implements be found in them, the map (Fig. 16, Plate V.) is given to show the position of the several pits described, as it would otherwise be difficult to define their situation. Moreover the pits are very extensively worked and may ultimately run one into another. The map was reduced from parish surveys of Surlingham and Rockland, kindly lent to me by Mr. C. J. Hornor.

Surlingham.—Pit A. (*See* Fig. 17, Plate VI.) showed in the central and deepest part the following beds (1878):—

	Feet.
4. Brown clay and gravelly loam resting in hollows on bed below, with patches of chalky Boulder Clay at the western end - - - - - - - -	1 to 5
3. Very stiff unctuous blue clay, with streaks of mottled reddish-brown clay, micaceous and sandy in places, rudely laminated - - - - - - - Alternations of blue and brown clay - - -	10 to 12
2. Brown and yellowish-grey laminated micaceous sand and clay with hard jointed beds - - - - -	4
1. Yellow sand.	

The western end of the bed showed that the blue clay which occupied a trough or basin, the result of disturbance and denudation, was remarkably contorted at this extremity. And the brown clayey capping contained at one time (1877) a mass of chalky Boulder Clay 5 feet in thickness, and as the pit was

* Quart. Journ. Geol. Soc., vol. xxxvi., p. 497; *see also* Geol. Mag., Dec. II., vol. iv., p. 551, and S. B. J. Skertchly, Manufacture of Gun-flints, &c. (Mem. Geol. Surv.) p. 65.

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worked back (1878) it displayed several isolated patches of this Boulder Clay, thus indicating that the brown clay was really the weathered portions of this glacial bed.

Pit B. (fig. 17) showed the following section :—

	Feet.
Sandy and gravelly warp with irregular patches of grey clay	2 to 4
Blue and brown mottled clay and laminated clay and sand	3
Dense blue clay (bottom not seen)	10

Rockland.—Pit C. was a deserted pit, from which the clay had been dug and hauled up in barrows on an inclined plane by aid of a windlass.

It showed alternations of blue and yellow clay on the southern side, while on the opposite side of the pit chalky Boulder Clay was exposed.

Pit D. showed a basin of blue clay capped by traces of chalky Boulder Clay, and underlaid by grey and buff laminated clay, containing hard marly beds. This blue clay when burnt forms white bricks, and the brown clay forms red bricks. Both contain much *race* called "Dodmans" by the workmen.* The blue clay, wherever I have seen it, rests on top of yellow and grey clay, both occupying hollows.

Pit E., known as the "White Earth Pit," showed in one face the blue clay (D) underlaid by the greyish-yellow laminated clay (B), squeezed up into a synclinal, and overlaid by brown clay with traces of chalky Boulder Clay (E). Chalky Boulder Clay (A) also occurred below. (*See* fig. 18, Plate VI.) Mr. Whitaker observed that the greyish-yellow beds were probably altered by water coming up. On the opposite face of the pit these beds, about 6 feet in thickness, came up to the surface, and alternated with hard jointed marly beds. Chalky gravel (C) was to be seen in one part of the pit, and the beds were covered with a loamy soil or warp (F).

Forty yards to the north a pit was opened in sand to a depth of 20 feet or more, which most probably belongs to the Crag series. (*See* p. 84.)

The blue clay in this pit when burnt forms white bricks. (*See* p. 84.)

A humerus of Elephant has been recorded by Mr. J. E. Taylor from the Rockland brickearth.†

In several other localities beds of laminated brickearth occur, always in association with the chalky Boulder Clay, being sometimes not only overlaid but also underlaid by it. This is the case with the brickearth north of Thetford railway station. My colleague Mr. F. J. Bennett has observed that in the neighbourhood of Diss, the laminated brickearth met with here and there is directly overlaid by the chalky Boulder Clay, and rests on the sands and gravel called "Middle Glacial." A similar arrangement is mentioned by Mr. Blake in his description of the sections at Freethorpe. (*See* p. 102.)

This laminated brickearth differs in character from the Stony loam or Contorted Drift, and occupies a different position; it is true that at Diss railway station the laminated brickearth is remarkably contorted, but as I have elsewhere remarked (*see* pp. 116, 137), beds of very different ages in Norfolk are "contorted." Most of the disturbances are traceable to the agent which formed the chalky Boulder Clay, and to this agent I attribute the disturbances that have affected these laminated brickearths at Rockland and Surlingham. The lower patch of chalky Boulder Clay, in the White Earth Pit may very likely be an intruded tongue of that formation, which, as is well known, is occasionally wedged into or forced under older deposits.

Howe.—The following section was exposed about a quarter of a mile west of the church :—

Bluish-grey chalky Boulder Clay with pockets of sand	3 feet.
Brown and grey chalky Boulder Clay	6 to 8 inches.
Buff sand with chalky grains	10 feet.
Clayey sand	1 „
Grey finely laminated clay and sand, with gravelly layer 2 feet 6 inches from base	7 to 8 „
Sand and chalky gravel with flints.	

* "Race" is a concretionary and septarian form of carbonate of lime.

† Proc. Norwich Geol. Soc., vol. i., p. 9.

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The opposite face of the pit on the west showed nothing but chalky Boulder Clay.

At Howe Green the Boulder Clay was to be seen resting upon about 15 feet of sand and laminated clay with pockets of gravel. The sand contained chalk pebbles.

Yelverton.—*See* p. 125.

Poringland.—A quarter of a mile north-west of the Dove Inn is a laminated brickearth, which is both overlaid and underlaid by the chalky Boulder Clay; and this is above the stony loam which is seen not far off at Howe. (*See* p. 105.)

The section was as follows:—

	Feet.
5. Brown clayey soil	2 to 3
4. Chalky Boulder Clay	6 to 7
3. Chalky sand	
2. Yellowish laminated clays and hard marly beds	6
1. Chalky Boulder clay.	

Shottesham.—The brickyard showed fine laminated sandy brickearth and stiff blue and grey mottled clay, 5 feet in thickness. (*See* p. 105.)

Newton Flotman.—About half way between Newton and Swainsthorpe churches a brickyard exposed the following section (Fig. 20, Plate VII.):—

		Feet.
Glacial drift	Brown clay	2 to 3
	Chalky Boulder Clay	
	Veins of chalky sand, impersistent—	
	Brickearth, bluish-grey clay and loam with few stones, many nests of sand, much contorted	5 to 6
	Sand and loam in alternate bands, laminated and slightly contorted	4 to 5
Upper Crag?	False-bedded buff and white sand, with a few stones	6

Here the Brickearth was evidently contorted by the agent which produced the chalky Boulder Clay.

Tharston.—At the brickyard here were manufactured the bricks used (in 1847) for the Great Eastern Railway arches.

The pit showed chalky Boulder Clay resting on whitish clay and grey laminated brickearth, and also underlying it. The whole thickness varied from 8 to 10 feet.

Stratton St. Michael.—About half a mile north-east of the church the following section was to be seen:—

	Feet.
3. Brown clay, the weathered residue of chalky Boulder Clay, with patch of Boulder clay	3
2. Chalky sand	2½
1. Laminated sand and marly brickearth, more sandy at top	12

Beneath these beds in another part of the pit was exposed 9 feet of buff and yellowish-brown false-bedded sand with seams of fine chalky gravel.

The brickearth, where it came to the surface at one part of the pit, was eroded or "piped" similarly to the Boulder Clay.

Raveningham.—In a pit north of the *h* of Raveningham Field (on the map) from 8 to 10 feet of chalky Boulder Clay was to be seen, with an included mass, 4 feet in thickness, of laminated sand and clay.

Hedenham.—The brickyard here showed the following section, which was noted by Mr. C. Reid:—

Laminated brickearth	10 or 11 feet.
"Pan"	5 or 6 inches.
Chalk gravel	said to be 3 feet+

The brickearth is used for white bricks and drain pipes, red and white tiles, vases, and other ware.

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On the west side of the kiln loamy sand, said to rest on gravel, has been worked for about 5 feet; it is on a level with the top of the brickearth across the road, and may cover it (probably it is a Post-glacial deposit).

[C. Reid.]

Here was formerly a Roman kiln which has been described by the Rev. S. W. King.* He observed that "the interior, from top to bottom, shewed the "action of intense firing on the native clay, out of which the kiln was "scooped, and which formed its sides. What seemed on a first glance to be "rude courses of brick were only the varying beds of stratified brickearth, "which had, in burning, taken different shades of colour, red or white, as the "thin beds were more or less sandy or clayey."

Strumpshaw, &c.—In his Report on the Agriculture of Norfolk (p. 13), Mr. R. N. Bacon says, "On the hill at Strumpshaw, the highest ground in "the county, there is a fine blue clay, differing totally from all the surround-"ing fields."† This hill, and that at Poringland Heath, both of which are covered with a thick deposit of gravel, have been coloured as "blue clay" in S. Woodward's Geological Map of Norfolk. It is just possible that a bed of clay, of economic value, was opened up in the gravel at Strumpshaw; in which case it might have been a transported mass of beds of the age of the "laminated brickearth" of Rockland, &c. (*See* p. 130.)

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* Norf. and Norwich Arch. Trans., vol. vi., p. 149.

† The highest ground in Norfolk is probably between Dereham and Swaffham, one point on the Ordnance Map at Little Fransham being marked 268 feet.

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CHAPTER V.—GLACIAL DRIFT (*continued*).

D.—Boulder Clay (Chalky Boulder Clay).

This Boulder Clay is generally a bluish-grey unstratified clay, with numerous pebbles, pellets, or knubbles of Chalk, and broken or comparatively unworn flints. The Chalk is often sufficiently abundant to give a whitish hue to the deposit; hence it is called the Chalky Boulder Clay. Occasional boulders of quartz, limestone, grit, septaria, and igneous rocks are met with. Veins and beds of sand, and pockets filled with Chalk pebbles, are not unfrequent. Its maximum thickness in the district is probably 50 feet.

In former days the Boulder Clay was extensively dug as marl for agricultural purposes, to which the numerous old pits sufficiently testify, but at the present day this application is almost discontinued, the artificial manures and the chalk-lime taking its place. In a few localities the stones are used for road metal, and some of the pits have been marked as "gravel pits" on the Ordnance Survey Map.

Many derived fossils have been obtained from the Boulder Clay, among the more conspicuous of which are:—*Gryphæa incurva* (Lower Lias), *G. dilatata* (Oxford Clay); *Ammonites* from the Lias, Kimeridge Clay, and Oxford Clay; *Belemnites abbreviatus* (Corallian and Oxford Clay); *Cardinia* (Lias), &c. Among the erratic blocks are Lias, Oolites, Oxford Clay, Kimeridge Clay, Red Chalk, Chalk and flint, &c.*

One feature supposed to distinguish this clay from the Stony Loam or Lower Boulder Clay is the absence of shell fragments, but it is by no means improbable that the stronger shells of the Crag period, such as *Cyprina Islandica*, might be caught up and preserved in it, as well as Liassic and other older fossils, or as the shells of the Kimeridge and Oxford Clays. And indeed shell-fragments have been noticed by Messrs. Bennett, Blake, Skertchly, Reid, and myself in the Boulder Clay at Flordon, and near Rockland St. Mary.

The chalky Boulder Clay, as remarked by Mr. Penning, "rarely " presents any signs of stratification,"† and so far as I have observed, it is devoid of any signs of deposition under water, for the rude bedding occasionally visible is of a kind that might be produced by one layer being forced over another on land. It is a kind of bedding without real stratification, for the component materials are not arranged in layers.‡

The chalky Boulder Clay is on the whole the most uniform

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* *See* list by John Brown, of Stanway, of specimens identified by J. de C. Sowerby and S. P. Woodward, Proc. Geol. Soc., vol. iv., p. 165; also Mag. Nat. Hist., vol. ix., p. 42; J. Morris, Geol. Mag., vol. v., p. 411, and S. Woodward, Geol. Norfolk, p. 89.

† W. H. Penning, Explan. of Sheet 47 (Geol. Surv. Mem.), p. 59; Quart. Journ. Geol. Soc., vol. xxxii., p. 195.

‡ *See* H. B. W., Proc. Norwich Geol. Soc., vol. i., p. 60; C. Reid, Geol. Mag., Dec. 2, vol. vii., p. 58.

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and easily identified of the Glacial deposits. Indeed it does not vary to a very extreme degree in its extension from Norfolk through Suffolk to Finchley, where 50 years ago it was traced by R. C. Taylor.*

While its general character is uniform and its distribution wide, yet it is very irregular in its minor features of relation to other deposits. Sometimes the boundary is even or gently undulating, and then the Boulder Clay makes sudden and irregular plunges to the bottoms of the valleys, giving rise to the notion that they were excavated prior to the formation of the Clay.† This, however, is not borne out when studied in connexion with the shape of the valleys. And the conclusion warranted by the facts, is that the Boulder Clay formed or filled old valleys which have sometimes been re-excavated along the line of the present valleys. By its formation the old scenery that had resulted previously was effaced. It formed a plain extending far and wide over the eastern counties. Hence while we find the boundary often running along the borders of the river valleys in conformity with the features, at a regular level for some distance, we can never depend upon its persistence. (*See* p. 146.)

So irregular is its position that the Boulder Clay rests upon any older bed from the Chalk upwards. We see it directly upon the Chalk near Trowse, Intwood, and Thorpe, upon the Norwich Crag at Postwick, upon the Lower Glacial brickearth at Upton, and upon the Glacial sands at Mackie's nursery. And at the same time the underlying beds are not unfrequently contorted. Such is the case with the Chalk at Trowse, with the Crag at Postwick and Surlingham, with the brickearth near Catton and Sprowston, with the laminated Glacial beds at Surlingham, Rockland, and Swainsthorpe.

Along the valleys the Chalk is not unfrequently disturbed where no traces of chalky Boulder Clay now remain, but all evidences of disturbance occur, so far as I am aware, in districts where this Boulder Clay is not far distant, or where it may formerly have been present. I know of no such disturbances in the Chalk of the Bure Valley where no Boulder Clay is near. Hence the term Contorted Drift (applied to the Lower Glacial Brickearth) is ambiguous, as any formation may have become contorted by the agent which formed the chalky Boulder Clay.

Where the Boulder Clay comes near the surface it is furrowed or "piped" like the Chalk, and this surface material is sometimes like that called "Dead Lime" at Brandon (so Mr. Skertchly informs me), and also like the contorted chalky loam seen above the Chalk in the lower part of the pit at Hartford Bridge. This loam may be the relic of a patch of chalky Boulder Clay almost entirely destroyed by denudation. (*See* pp. 137, 140.)

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* Letter to S. Woodward, 25 March 1829.

† *See* Wood and Harmer, Geol. Mag., vol. v., p. 455; Quart. Journ. Geol. Soc., vol. xxxiii., p. 74; vol. xxxvi., p. 493, &c.; and W. H. Penning, Quart. Journ. Geol. Soc., vol. xxxii., p. 191.

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The chalky Boulder Clay weathers into a brown loam as may be seen in numerous pits at Newton Flotman, Stratton St. Michael, Upton, &c. And in many instances it is hard to distinguish this loamy surface soil from the Contorted Drift, as near Burlingham and Lingwood.

Respecting its agriculture the district occupied by the chalky Boulder Clay constitutes the heavy land or "stiffer soils" of Mr. C. S. Read, which covers the greater portion of the area embraced by Quarter Sheet 66 S.E.; the country around Hethel and Mulbarton, Bramerton and Yelverton, Brooke, Thwaite, Topcroft, Long Stratton, Hardwick, and Tivetshall. This is described by Young* as a "strong loam" or "clay marle." Beans and wheat grow well on it.

The Boulder Clay country has sometimes a park-like aspect, with strips of grass-land bordering the roads, as near Saxlingham: it is, moreover, characterized by numerous greens and commons, as at Wacton, Pulham, Mulbarton, &c. On its surface are numbers of ponds, like the Brooke Meres, that have been excavated for various purposes, some being old marl pits, others having been dug as tanks to supply water not only for cattle but for the human population, as in the neighbourhood of Hempnall, Alburgh, Stratton St. Michael, &c.

In the neighbourhood of Hardwick, Tivetshall, &c., bricks are made, after the fashion of the Egytians of old, out of the chalky Boulder Clay. The material dug is mixed with chopped straw, and then puddled and dragged about in a mill by horses, after which it is put in moulds about 18 inches or 2 feet in length, by 6 or 8 inches in breadth, and then dried in the sun.

Mr. J. G. Nall speaks of these brickmakers as "daubers," stating that "In the large barns and farm buildings of East "Anglia, artificers in *wattle and daub*, a mixture of clay or mud "with stubble or short straw, well beaten and incorporated, "sometimes strengthened with laths and hazels, were formerly "in great request."†

These bricks are used in the construction of barns and other buildings, but, as I am informed by my colleague Mr. F. J. Bennett, are best employed as an inside casing. Houses that are built of the somewhat porous bricks made out of the Glacial brickearth, are thus kept very dry.

The term Mudgin (or Mergin) is sometimes applied to marly deposits or to the refuse of old walls and buildings, which being mixed with clay, straw, &c., has been used for constructing hovels, &c.

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* Agriculture, 1804.
† Glossary of the Dialect and Provincialisms of East Anglia, 1866.

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Local Details.

1. *Area North of the Yare.*

Haveringland.—The Boulder Clay may be seen in a pit at the south-west corner of Mile Stone Covert; and in several large pits west of Bee Cross and in the adjoining area of Quarter Street 66 N.W. The boundary is not well defined.

Attlebridge.—South of Spring Farm is a section showing in one part of the pit brown clay resting on bluish sandy, pebbly, and chalky Boulder Clay. This has been grouped on the map with the Lower Glacial.

Costessey.—The section at the brickyard, near Water Lane, about 20 feet in depth, showed the following beds:—

	Feet.
Sandy soil	3
Chalky layer	1 to 1½
Pockets of brown clay.	
Chalky Boulder Clay, rather loamy, with pebbles and fragments of flints, unworn flints, chalk stones, boulders of quartz and mica schist	18
Buff and grey sand, stratified—base not seen (Upper Crag)	6

The bricks used in building Costessey Hall were made here. Pipes, ornamental bricks, and vases are also manufactured.

Hellesdon.—A section north of Clements' Mill, on the east side of the high road, showed:—

Brown soil Fine false-bedded gravel and sand Chalky Boulder Clay, with nests of sand and bed of fine brickearth	10 feet.

The Chalk is exposed a little lower, but the junction was not shown.

Thorpe.—Chalky Boulder Clay may be traced on the Chalk in the road cutting by the Asylum. And traces were at one time to be seen in the cutting of the East Norfolk Railway just beyond the Lime Kiln.

Mr. J. E. Taylor thus describes the section:—"In the cutting of a deep "railway gulley, close by the well-known Crag-pit of Thorpe, near Norwich, "there was laid open, about a couple of years ago [1867], a section showing a "north-easterly groove scooped out of the sand and pebble beds, and having "the Upper Boulder Clay dropped into it. The diameter of the furrow was "about 100 yards. On each side the sands were twisted and contorted, as "though they had been acted upon by some moving mass, and thrown out "of their original position."*

Mr. S. V. Wood, junr., subsequently described the same section. He says, "This cutting was made through the north side of the Yare Valley, and in it "the chalky clay was exposed with the Middle Glacial sand, containing its "shell-bed under it, on the upper part of the valley side; but lower down the "whole of the clay had been ploughed out, and the sand was all twisted up "with the Lower Glacial (Bure Valley) sand."†

Postwick, &c.—A little to the N.E. of the 128th milestone on the Norwich and Yarmouth Railway, the chalky Boulder Clay is shown in a pit to rest directly on the Chalk, as it does a little further west. From this point it stretches up the hill-slope to the south-east, and at one point in Postwick Grove was detected above the Norwich Crag by my colleague Mr. Whitaker. In the cuttings of the railway it rests here and there on the Crag which appears considerably disturbed, as was also the case with the beds in the cutting on the Cromer line not far distant.

The junction between the Boulder Clay and Contorted Drift is very vague, both south of the barn in Postwick parish, and in its boundary through Great Plumstead, Witton, and Brundall parishes. From the evidence furnished, it

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* Geol. Mag., vol. vi., p. 509.

† Geol. Mag., Dec. 2., vol. iv., p. 549; and Quart. Journ. Geol. Soc., vol. xxxvi., p. 495, and Fig. 18, Plate XXI.

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might be concluded that the Boulder Clay and Contorted Drift were one and the same thing, and when mapping this district I was for some time disposed to hold this view. It is a striking fact that where the chalky Boulder Clay is well developed, as over the country south of the Yare, the Contorted Drift is almost entirely absent, while to the north of this river, where the Contorted Drift spreads over a large area, the chalky Boulder Clay is only met with in a few localities. When, however, a section like that at the pit N.W. of Upton Church is examined, it throws light on the structure of these tracts. (*See* pp. 94, 100, 103.)

Strumpshaw, &c.—The surface of the country around Strumpshaw, Lingwood, Burlingham, Hamlington is covered with chalky Boulder Clay much obscured by a loamy soil, so that it is difficult to distinguish it from the Lower Glacial brickearth. When, moreover, we find the beds so irregular, as witnessed at Hamlington and Upton, the difficulties of the mapping are increased. Hence the boundary of chalky Boulder Clay and Brickearth in this tract is vague. (*See* Figs. 13 and 14, Plate IV.)

Several large pits show the chalky Boulder Clay with 3 or 4 feet of buff sand at its base, but this sand is very irregularly displayed on the surface.

Large pits occur south of Strumpshaw Hill (25 feet of Boulder Clay), and between Burlingham House and the Old Manor House, Burlingham St. Andrew (15 feet). Near the Old Hall, South Burlingham, the soil was described to me as "thin skinned land," or land with little soil on heavy clay or stony loam.

A pit north of the Plantation, South Walsham, showed the chalky Boulder Clay with irregular masses of sand and chalky gravel. (*See* p. 114.)

The following notes are by Mr. BLAKE:—

Southwood.—A clay pit is situated nearly half a mile S.S.E. of the church, on the west side of the road, where a considerable quantity of clay has been excavated to put on the fields. From 7 to 8 feet in thickness of chalky Boulder Clay was exposed, apparently overlying reddish-brown loam. I observed a few well striated boulders, about a foot in diameter, one being a limestone containing numerous specimens of *Gryphæa incurva*, in fact, consisting almost entirely of them.

Freethorpe.—Chalky Boulder Clay is shown overlying loam in the brickyard situated 1¼ miles N. of Reedham Railway Station. The Boulder Clay is exposed on the south and west side of the brickyard, and varies from about 4 to 9 feet in thickness. Some of it is shown to lie at a lower level, and some on the same level, as the sand which occurs in considerable thickness in the north-west corner of the brickyard. A well striated boulder, about 5 feet in diameter, occurred in the clay, which latter was of a grey colour, and contained numerous rolled flints and pieces of Chalk.

In a pit half a mile S.W. of Halvergate Church about 6 to 8 feet in thickness of chalky Boulder Clay is shown overlying loam, resting in a hollow of the latter. The Boulder Clay was of a grey colour and very chalky.

Moulton.—A clay pit is situated three-eighths of a mile N. of the church. The clay was of a grey colour and contained numerous pieces of chalk—a thickness of 9 feet was exposed. It apparently rests on loam, but the junction was not shown in the pit; loam, however, occurs all round. This chalky Boulder Clay, at this particular spot, stretches down from the high ground nearly to the level of the marshes. On the high ground, sand intervenes between the Boulder Clay and loam, as shown on the Geological Survey map.

About 9 feet in thickness of chalky Boulder Clay is exposed in a pit a quarter of a mile W.N.W. of Moulton Church. This clay in all probability here rests on loam, as I could detect no sand intervening on the slope of the hill to the north of the pit. The clay contains numerous small rounded fragments of chalk, and is irregularly overlaid—as is so frequently the case—by reddish-brown stony loam, 3 or 4 feet in thickness.

Acle.—A clay pit occurs three-eighths of a mile S.W. of the church, on the upper part of the slope of the valley, north of Jolly's Lane. From 8 to 9 feet in thickness of very chalky grey clay, weathering a yellowish-white, was exposed overlying brown loam with from 1 foot to 1 foot 6 inches of brown loamy sand intervening. The soil consisted of a stiff reddish-brown loam,

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containing many scattered large subangular flints, irregularly overlying the chalky Boulder Clay.

Another clay pit is situated a little more than three-eighths of a mile N.N.W. of Acle Church, on the north side of the road. About 7 or 8 feet in thickness of very chalky grey clay was exposed, with a little reddish-brown loam irregularly overlying the same. I was informed that there was loam underlying the clay with about 1 foot in thickness of sand intervening.

Fishley.—In a clay pit about 200 yards S.S.E. of Fishley Church, about 10 feet in thickness of chalky grey clay was shown, containing large flints, striated limestone, and other boulders. The clay apparently overlaid sand, from the presence of rabbits in the bottom of the pit, &c.; but no good section showing this was exposed, the pit being too much overgrown.

Stokesby.—I observed chalky Boulder Clay in the churchyard, and was informed that 7 feet in thickness of this clay overlies sand there.

A large clay pit occurs in the field to the E. of the church, but is now ploughed over and no section was exposed.

Some smaller pits, also more or less filled in, are situated to the E. of the above pit in the adjoining fields, where I was informed chalky Boulder Clay overlaid sand. I noticed this clay in one of them.

Oby.—A clay pit occurs a little more than a quarter of a mile S.E. of Thurne Church, where 10 feet in thickness of chalky Boulder Clay was exposed.

Another clay pit is situated about a mile E. by S. of Thurne Church, in a field on the east side of the road leading to Ashby Hall. Chalky Boulder Clay, 10 feet thick, was shown overlying sand.

Thurne.—About 150 yards S.W. of the church, on the south side of the road, chalky Boulder Clay of a grey colour, weathering a yellowish-white, 9 feet thick, is shown overlying loam.

J. H. BLAKE.

Lakenham.—One of the most interesting sections near Norwich is at the pit known as Mackie's Nursery on the eastern side of the Ipswich Road, about one mile from the city gates.

In this pit a long face of chalky Boulder Clay is exposed, resting upon buff false-bedded sands.

The upper portion of the chalky Boulder Clay is in places piped by the action of acidulated water, and the material much resembles the "dead lime" at Hartford Bridge. (*See* p. 137.)

At the northern end of the pit the Boulder Clay is capped by sands with chalk grains.

The following is the section, which is illustrated in Fig. 12, Plate IV.:—

	FEET.
4. Soil 3. Red and brown sand, gravelly, and with small chalk pebbles	6
2. Chalky Boulder Clay	4 to 8
1. False-bedded sand.	

The mode of occurrence of the Boulder Clay suggests the idea of its being a lenticular mass, both here and also at Tuck's Wood Farm,* where 8 feet of Boulder Clay may be seen resting on the sand. The clay is in places bedded, though not stratified; that is to say, the materials themselves are not arranged in layers.

At the south end of the pit I noticed, in 1878, that the sands were distinctly contorted in one place.

The Boulder Clay was shown in a pit in the nursery grounds of Messrs. Daniels to the depth of 2 ft. 6 in., resting on sand.

At Hartford Hill House a section showed about 10 feet of chalky Boulder Clay, with its upper surface furrowed by pipes filled with brown clay, and trending generally a little to the N. of W.

The Boulder Clay may be traced across the railway by Trowse Junction

* *See also* Wood and Harmer, Quart. Journ. Geol. Soc., vol. xxxiii., pp. 83, 86.

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(where a large pit may be seen*) to the borders of the River Yare a little south of Lakenham Church.

This fact of the chalky Boulder Clay running from the high ground quite to the bottom of the valleys is no unusual occurrence. It is found at other parts of the valley between the "Cock" Inn and Trowse Millgate, and is well known to occupy similar positions in the Waveney Valley.

It is by no means clear that the Boulder Clay is newer than the sand of the Town Close property. In fact its lenticular position would seem to indicate that it may belong to the same set of beds.

The sand underneath the Boulder Clay at Mackie's Nursery was here and there at the line of junction hardened into great concretionary lumps or "doggers." This was no doubt produced by carbonate of lime from the chalky Clay above. The following analysis of the "sandstone" was made by Mr. F. Sutton:—†

Carbonate of lime	3·50
Peroxide of iron	·13
Alumina and Organic matter	·29
Pure sand	68·38
	72·30

S. Woodward (MS.) thus described the beds beneath the Boulder Clay in 1825:—

	ft.	in.
Sandstone	4	0
Orange-coloured sand	1	0
Lilac-coloured sand	0	6
Orange-coloured sand	1	6
White sand in oblique layers, with fragments of shells	4	0
White sand in horizontal layers	10	0
	21	0

He was "inclined to think, from the size of the cavity and similarity of the "stone, that it was used to build Norwich Castle." The white sand, with fragments of shells, he further describes as "sand containing about 30 per "cent. of comminuted particles of shells."‡ The Rev. O. Fisher has more recently spoken of the sand at this pit (he calls it Firgrove Pit, Mile End, Norwich) as containing Foraminifera derived, in the opinion of Mr. J. E. Taylor, from the Chalk and Boulder Clay.§

East of Hartford Bridge, Boulder Clay may be traced by the railway, and was probably dug from a pit north of the 123 milestone. This may have been the pit mentioned by Arderon as "near two furlongs from Hartford Bridge "... in which the country people dig a particular sort of clay—to lay "upon the sandy lands." He noted the occurrence of *Ammonites, Belemnites*, septaria, &c.‖

Earlham.—A chalk-pit on the slope of the hill south-west of Earlham Lower Farm showed on the surface, in one part of the pit, about 3 feet of chalky loam with chalk pebbles and pebbles of flint, quartz, &c. This was underlaid by an irregular seam of sand.

2.—*Area between the Yare and the Waveney.*

Colney.—A pit about half way between Lascoe Plantation and Hall Farm, Little Melton, showed about 12 feet of chalky Boulder Clay with pipes of brown clay.

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* This pit I first visited under the guidance of Mr. Harmer, who regards the deposit as Lower Glacial. *See* Quart. Journ. Geol. Soc., vol. xxiii., p. 87; vol. xxxiii., pp. 83, 86.

† *See* Geol. Mag., vol. iii., p. 43.

‡ *See also* Geology of Norfolk by S. Woodward, p. 19.

§ Geol. Mag., vol. v., p. 551.

‖ Phil. Trans., vol. xliv., pp. 275, 283; Abrid. by Martyn, p. 592.

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Little Melton.—West of the Hall Farm a pit showed about 4 feet of sand and loam with angular flints (one of which was ice-scratched), resting on very sandy Boulder Clay.

Cringleford.—South-west of Newfound, Colney, the Chalk with flints was capped by about 9 feet of sandy and stony loam, possibly a relic of the Crag series worked up during the formation of the chalky Boulder Clay.

At the end of the lane, south-west of Newfound, a large pit showed the Boulder Clay much mixed up with sand, resting on false-bedded chalky and carbonaceous sand, about 5 feet of which was exposed.

About half a mile north of Thickthorn a pit showed Boulder Clay resting irregularly on buff sands.

Hethersett.—The Boulder Clay south of Cantley White House is much obscured by loamy soil. An old pit showed the beds to be very irregular, with sand, gravel, and boulder clay in inextricable confusion.

Intwood.—A pit east of Intwood Hall showed the following beds :—

	FEET.
E. Brown stony clay soil - - - - -	12
D. Very chalky marl - - - - -	
C. Sandy and chalky clay, with chalky and sandy seams and many boulders of chalk, flint, sandstone, and shale - -	
B. Seams of sand and pebbly gravel, with occasional large unworn flints - - - - - - -	
A. Chalk with flints, somewhat disturbed.	

These beds (B. to D.) might by some geologists be grouped with the Lower Glacial, but I could not separate them from the chalky Boulder clay.

South of Cringleford Hall the following section was exposed in an old pit now overgrown with trees :—

3. Gravel, pebbly and sandy, 3 or 4 feet, irregular.
2. Chalky Boulder Clay in patches.
1. Chalk with flints.

Keswick.—East of the new Hall (residence of F. Hay Gurney, Esq.) Boulder Clay was to be seen resting on sand ; to the south is a shallow road cutting in sand and gravel.

The Boulder Clay itself in this district is interbedded with sand, as may be seen east of the high road near Keswick Church.

South-east of the church a pit showed the following beds, which were inclined on one side of it :—

Brown Clay.
Sandy Boulder Clay.
Chalk-gravel, and sand.
Blue Boulder Clay, 6 to 8 feet.
Stratified sands, slightly hardened.
Boulder Clay, 8 to 10 feet.

Markshall.—South-east of the barn near Keswick the chalky Boulder Clay contained interbedded masses of sand and gravel.

Swainsthorpe.—S. of the Dun Cow Inn a pit showed chalky Boulder Clay resting on 6 to 8 feet of sand, chalky gravel, and chalky loam; the whole reposing on the Chalk. (*See* p. 134.)

Boulder Clay was dug at "Sprows-pits."

Ketteringham.—North of the Hall Close Plantation a brickyard was opened in a loamy deposit resting on the chalky Boulder Clay; 3 to 4 feet of it was dug.

East Carlton.—South-east of Park Lane a marl-pit showed on one side the following beds :—

Loamy and pebbly soil, contorted marl, sand, and gravel.
Marl, with a few flint pebbles, several large unworn and broken flints, and lumps of hard chalk, 6 feet.

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On the other side of the pit ordinary chalky Boulder Clay was exposed.

N.E. of Carlton Lodge was a pit 15 to 20 feet deep, showing Boulder Clay on one side; pebbly gravel, and sand on the other.

*Hethel.**—West of Hill Farm, Hethel Bridge, a temporary brickyard showed:—

	Feet.
Loamy soil, with traces of chalky Boulder Clay - - -	4 to 5
Stiff blue sandy and stony brickearth - - -	4

Chalky Boulder Clay was shown at the base in one place; hence this brickearth is probably a weathered surface of Boulder Clay.

Flordon.—Chalky Boulder Clay was well shown in the cuttings of the railway, and the late Mr. John King obtained from near the station, bones of *Plesiosaurus*, *Pliosaurus*, and *Ichthyosaurus*.

Below the church, Boulder Clay rests directly on the Chalk. In a pit about half a mile W.S.W. of the Hall, the following section was to be seen:—

	Feet.
Brown clay with angular flints.	
Chalky Boulder Clay with weathered surface - -	4 to 10
Fine stratified and false-bedded chalky sand, with seams of chalk and flint-gravel - - - - -	6 to 8

One side of the pit is made up of chalky Boulder Clay alone.

It was in the chalky Boulder Clay here that Mr. Reid found fragments of shells, either Pliocene or Pleistocene.

Hapton, Forncett, Ashwell Thorpe, &c.—West of the church the road showed a deep cutting in the Boulder Clay.

About half a mile west, and in the parish of Fundenhall, an old marl-pit showed a loamy and chalky clay with few stones.

In the railway cutting (main line) traces of chalky Boulder clay were noticed by Mr. Whitaker beneath the coarse gravel, and resting on the pebbly gravel. The gravel-pit south-west of the bridge also showed traces of this Boulder Clay.

Chalky Boulder Clay was well shown in cuttings of the new line of railway south of Hapton, and the way in which it had lost its calcareous matter by atmospheric action was remarkably well exhibited in one place. (*See* Fig. 22, Plate VII.) This was in the cutting near Low End, where the following beds were displayed:—

d. Gravelly soil.
b. Chalky Boulder Clay, passing into *c*. Brown clay or stony loam.
a. Grey and yellow sands and pebble gravel; in places contorted (Upper Crag).

Here the weathered portion of the Boulder clay (*c*) was so like the Stony loam (Contorted Drift), that if only the portion of the cutting showing it had been opened up, the bed would most likely have been regarded by all observers as Lower Glacial.

Near Forncett the Clay contained boulders of Red Sandstone, Red Chalk, Oolite, but chiefly Chalk and Flint. Nests of Chalky Gravel occurred in it.

North of Wood Lane, Tharston, the Boulder Clay is underlaid by fine chalky gravel and buff sand.

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* Spelt Heathel on the sign-posts.

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West of Hapton the Boulder Clay was also well shown in the railway-cuttings, and in one section the appearance of "bedding" or "streak" was conspicuous, the beds indeed reminding one of the Lower Glacial tills of the Cromer coast. (*See* Fig. 21, Plate VII.) It seems quite possible that here we have representatives of them in point of age, but in that case the whole of the beds in the cutting, including some like the chalky Boulder Clay, must be similarly grouped. Speaking of the Cromer Beds Mr. C. Reid says, "Though these "tills are unstratified they often show a 'streak' like that of doughy bread or "piecrust. This, I believe, has nothing to do with a sedimentary origin; but "is simply formed like the flakes in piecrust by a sliding pressure from above."* This explanation well applies to the beds in this district, and if the chalky Boulder clay was formed, as the *moraine profonde* of an ice-sheet, such appearances might well be expected in it as we see represented in Fig. 21. (*See* p. 136.) The section was as follows:—

d. Brown loam.
c. Bluish-grey mud with streaks of chalky Boulder Clay.
b. Chalky Boulder Clay.
a. Sands (Crag series).

At Forncett St. Mary, sun dried bricks are made of the Boulder Clay. (*See* p. 117.)

North-east of the church a small brickyard has been opened up in brown stony clay to the depth of 6 feet. This appears to be a weathered surface of the Boulder Clay.

Trowse Newton.—About half a mile south-east of the church Boulder Clay is seen directly on the Chalk.

During the progress of the Norwich Sewer Works one of the shafts disclosed a hole or trough in the Chalk beneath the Valley Gravel of the Yare near Trowse village. The section was described by Messrs. Wood and Harmer in 1869; it showed some thickness of sand (which they grouped as Middle Glacial) and of Boulder Clay exactly resembling the chalky Boulder Clay. They then regarded the Boulder Clay as possibly a mass in the "Middle Glacial," and as indicating the Intra-glacial denudation of the Yare Valley;† the exact relation of clay and sand, however, was not clearly made out, and in a later communication they left the identification of the Boulder Clay as Middle or Upper Glacial an open question, contending only that the valley was excavated prior to the deposition of the Contorted Drift.‡

That the valley at this particular point was thus excavated in Glacial times I must admit, but my opinion is that its re-excavation here is but accidental, having no immediate relation to the present features of the valley.

I was informed by Mr. Harmer that brickearth was worked on the brow of the hill near Crown Point, for building the mansion on that estate. This was perhaps a patch similar to that at one time exposed above the Chalk in the Trowse Chalk-pit. (*See* Fig. 24, Plate VII.) The boundary of the Boulder Clay westwards towards Kirby Bedon is obscure, there being a loamy and sandy soil over it.

Kirby Bedon.—A sand pit south-east of the church-in-ruins, showed contorted chalky sand with seams of Boulder Clay. It could not be mapped distinctly.

Bramerton.—From this locality S. Woodward notes *Ammonites bifrons*, Brug., and *A. binus*, Sby., both probably Liassic species.§

Framingham Pigot and *Framingham Earl.*—In these parishes are several pits in the Boulder Clay, and this, according to Dr. Rigby, yielded Ammonites, and a good deal of shale, some of it bituminous.‖ This latter possibly led to the sinking in search of coal. (*See* p. 169.)

Yelverton cum Alphington.—A pit in this parish is said by Arderon (MS. Journal, July 28th, 1751), to have yielded clay which was "carried to London

* Geol. Mag., Dec. II., vol. vii., p. 58.
† Quart. Journ. Geol. Soc., vol. xxv., p. 445.
‡ Ibid., vol xxxiii., p. 82; *see* also vol. xxxvi., p. 495.
§ Geol. Norfolk, p. 42, and Morris, Catalogue, 2nd edit., p. 290.
‖ See his Account of Framingham, p. 47.

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" and Holland to make Delf-ware of. It is situate in a close bordering upon " Yelverton Common, about one mile south-east of the church, and is about four " or five yards deep from the surface." This is evidently the spot now called Kiln Grove.

S. Woodward, upon whose authority the above extract is given, quotes a passage from the "Magna Britannia," &c., p. 362, wherein it is stated that "A gentleman of this county, digging by chance in his ground, turned up a " fine clay, which some skilful persons observing, discovered the value of it to " him; whereupon sending it to Holland, where they made a choice sort of " earthenware of it, he made 10,000*l.* sterling of a piece of ground not 40 yards " square. Dr. Fuller tells this story, but suspects this sum as having a cypher " too much." S. Woodward thought that the locality of this valuable clay was probably that described by Arderon.* The clay may perhaps have occupied a basin, and been similar to that at Rockland. (*See* p. 112.)

Blomefield also mentioned that about the year 1336, "The *Dutchmen* " (Flemings) that came over first found *fullers earth*, a precious treasure, of which " there is more, if not better, than in all the world besides"; † but where this was I am not able to say. The Flemings, who landed chiefly at Yarmouth, settled at Worstead, Norwich, &c.

Surlingham St. Saviour.—At the church there is about 4 feet of sandy soil resting on chalky Boulder Clay.

A large boulder of igneous rock, about 22 cubic feet in bulk, lies at the N.W. corner of the churchyard.

Rockland St. Mary.—North-east of the church a pit showed Boulder Clay resting on buff sand with chalky seams.

The little patch of Boulder Clay south of the New Inn is a chalky loam, much like some varieties of the Contorted Drift, but equally like many beds that belong to the chalky Boulder Clay. Fragments of shells were noticed in it by my colleague Mr. Blake. (*See* p. 84.)

Hillington cum Holverston.—The Boulder Clay lies very irregularly on the ground between the church and Holverston Hall.

Claxton.—North of the Meeting House a pit showed :—

	Feet.
Brown sand	4
Chalky Boulder Clay, with *Gryphæa, Ostrea,* brown sandstone, quartz, &c.	12

A large pit south of Claxton Hall showed coarse gravel, resting upon chalky Boulder Clay, and this again upon buff sand in very irregular positions.

Ashby.—A pit west of the Hall showed 12 feet of Boulder Clay resting on 10 feet of buff false-bedded sand.

Thurton.—A pit south-east of the Red Lion Inn showed 8 feet of chalky Boulder Clay, with included loamy and sandy bed, resting on buff sand and sandstone.

About three-quarters of a mile east of Thurton Church a brickyard showed Boulder Clay resting on brown clay.

Burgh Apton.—A clay pit by the parsonage showed from 15 to 20 feet of chalky Boulder Clay resting on 5 or 6 feet of buff false-bedded sand, like that at Mackie's Nursery. (*See* p. 121.)

Langley.—The surface is very sandy, loamy, and in places gravelly, but the Boulder Clay is shown in many pits, as north of the church at Helsmere Hole, &c.

At the old sand-pit, Langley Street, traces of chalky Boulder Clay and chalky gravel occur in pockets and beds near the top of the sand.

At High Grove a brickyard was opened and a pit dug in sandy loam to a depth of 5 feet. This is perhaps weathered Boulder Clay.

Shottesham.—A good exposure of Boulder Clay, to which my attention was drawn by Mr. S. C. Sothern, was to be seen S.W. of the Round Park plantation. Here many scratched boulders and derived fossils have been obtained. (*See* also p. 169.)

Saxlingham.—West of the Baptist Meeting House the loamy surface of the Boulder Clay was worked for brickmaking.

* Geology of Norfolk, p. 15. A still earlier mention of this discovery is made by Samuel Hartlib, in his Legacie of Husbandry, 3rd edit., 1655, p. 97.

† Blomefield, 8vo. edit., vol. i., p. 85.

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Howe.—(*See* p. 112.)

Brooke.—The Brook Meres were excavated in the Boulder Clay. They may have been dug out for the marl, and are now serviceable as holding a water supply, unfit however for human consumption.

Sizeland.—North-west of the church the Boulder Clay was well shown; it contained many unworn flints, some broken, also large pebbles of chalk, septaria (glaciated), and a boulder of black shale. On one side of the pit was a (? included) mass of buff sand.

The following notes are by Mr. REID:—

Loddon.—The Boulder Clay was shown in pits around the Hall, and in the "gravel pit" east of the Town Farm.

Hales.—A quarter of a mile east of Loddon Hall a pit showed the following section:—

	FEET.
Soil	1
Boulder Clay	8
Fine white sand, the upper part hardened into a calcareous sandstone, for a foot or two	10

A sand-pit S. of Heckingham House of Industry showed about 15 feet of Upper Boulder Clay resting on fine sand. (*See* p. 106.)

Mr. Trimmer* has described a section near Raveningham Hall showing:—

3. Brown clayey loam	6 to 18 inches.
2. Boulder Clay	5 feet.
1. Sand (called "Crag") with false bedding	10 to 12 feet.

Raveningham.—A pit 3 furlongs S. of Crossway Farm, near Thurlton, showed 10 feet of Boulder Clay. (*See* p. 106.)

North of Daws Wood a pit showed a mass of Boulder Clay, 2 to 10 feet in thickness, resting on 15 feet of fine and minutely false-bedded white sand; at the junction of the two the sand was cemented into a hard bed.

Haddiscoe.—A pit a quarter of a mile S.W. of Haddiscoe Hall showed Boulder Clay resting on white sand.

Half a mile N.W. of the church 10 feet of Boulder Clay was seen resting on fine white sand.

Toft Monks.—A pit a quarter of a mile S. of Crossway Farm showed the following beds:—

	ft.	in.
Soil	about 1	6
Boulder Clay	about 8	0
Fine white sand.		

A pit on Bull's Green showed 15 feet of Boulder Clay. N.E. of the Green the Boulder Clay rested on sand.

Pits west of Aldeby Mill showed Boulder Clay resting on fine white and minutely false-bedded sand.

Half a mile W.S.W. of Aldeby Brickyard the Boulder Clay (10 feet) was capped by 2 feet or 3 feet of sandy wash. (*See* p. 106.)

Gillingham.—A pit S. of Gillingham Wood showed 8 feet of Upper Boulder Clay, resting on 3 feet of Glacial sand. (*See* p. 106.)

Geldeston.—East of the Brewery is a pit in sandy loam with chalk pebbles, curiously contorted, and showing small faults.

Stockton.—"At the side of the road, near the boundary of Stockton and "Hales, is a large stone, weighing about two tons, called "Stockton Stone," "and in the ancient Town book, still preserved, is an entry, dated 1645, recording "the payment of a small sum for putting *stulps* to Stockton Stone."†

S.E. of the Black Boy Inn there are two pits on the same level, one in chalky Boulder Clay to sand, the other entirely in sand.

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* Quart. Journ. Geol. Soc., vol. x., p. 237.

† White's History of Norfolk.

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Kirby Cane.—A pit a quarter of a mile N. of Leek Wood showed the following section :—

	Feet.
Soil - - - - - - - -	1½
Boulder Clay - - - - - - -	about 2
Bedded sand and marl, very irregular - - -	2 or 3
Boulder Clay - - - - - - -	8 or 10
Fine sand (Middle-Glacial) - - - - - -	4+

At the south corner of Kirby Green 5 feet of Boulder Clay was seen resting on 3 feet of Glacial Sand.

Kirby Row Marl-pit showed Boulder Clay resting apparently on pebbly sand.

At a spot called Pewter Hill, a corruption of Potter's Hill, an oven or kiln of Roman tiles was discovered by the Rev. G. C. Chester.* This spot is probably the same as the brick kiln (not now worked) half a mile west of the church. Here the section was said to have been "sandy loam capped with a "little gravel, and resting on loam."

A little further west by the farm, a pit showed about 6 feet of Boulder Clay overlaid, and to a certain extent replaced horizontally by finely false-bedded chalk gravel with some Boulder Clay: the whole resting on sands, of which 10 feet were shown.

Ellingham.—Near the centre of the Island, Boulder Clay was shown by the side of the road. N.E. of the Hall a pit showed about 8 feet of Upper Boulder Clay.

At the brickyard east of Broome Church about 6 feet of Boulder Clay was shown above 6 feet of fine sand.

Broome.—W. of the Hall Farm an old pit showed 3 or 4 feet of Boulder Clay resting on fine sand.

C. Reid.

Tasburgh.—A large pit at Tasburgh Hill showed the following succession of beds :—

		Feet.
Glacial Drift -	Irregular loamy gravel - - - -	15
	Chalky Boulder Clay - - - -	12
Upper Crag -	White sands - - - - -	20
	Laminated clay - - - - -	
	Stone bed - - - - -	
Chalk.		

Tharston.—In the cutting east of Horsford Water chalky gravel was shown at the base of the Boulder Clay.

In the pit at Furze Hill a patch of Boulder Clay was shown at the base of the coarse gravel. (*See* p. 131, and Fig. 10, Plate III.)

Stratton St. Michael.—Here a well was sunk through the Boulder Clay 33 feet to pebbly gravel. Further south I was informed by Mr. T. Barnham the Boulder Clay is 44 feet in thickness.

Mourning Thorpe.—A brickyard north of the Cider Factory showed a section of chalky Boulder Clay, with surface soil of brown clay. Both were used, the former being washed. Red and white bricks, tiles, and drain pipes were made.

Hempnall.—Boulder Clay was shown by the stream at the Poor House.

Hardwick.—Bricks were made here of chalky Boulder Clay and straw. (*See* p. 117.)

Alburgh.—S.E. of Darraw Green, a brickyard showed 4 feet of greyish-brown clay in the alluvial valley, resting on chalky Boulder Clay, but not sufficiently defined to map separately like the similar deposit at Hethel Bridge (p. 123).

Denton.—"A clay-pit E. of Denton, much overgrown, appeared to have been "dug through Upper Boulder Clay to pebbly gravel."

Earsham.—"A pit W. of Banter's Wood showed Boulder Clay passing "down to loamy clay with small stones, slightly bedded."†

* Norf. and Norw. Arch. Trans., vol. iv., p. 313.

† From Mr. C. Reid's Notes.

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3. Area south of the Waveney.

The following notes are by Mr. REID :—

Bungay.—W. of Annis Hill, the following beds were shown :—

Dark lead-coloured Boulder Clay full of chalk stones, unworn flints (one over 2 feet in diameter and striated), septaria, &c. - - - - -	10 feet.
Roughly-bedded loamy brown Boulder Clay, with small pieces of chalk and flint - - - -	about 7 feet.
Fine false-bedded sand - - - - -	7 feet shown.

Mettingham.—At the corner of the road north of the parsonage there was a block of Lias nearly 2 feet across in the Boulder Clay.

North of the Excise Office Ticket Bar the Boulder Clay occurs much lower in the valley than usual.

Shipmeadow.—In the wood half a mile south of the Hundred House of Industry a pit showed dark blue Boulder Clay (with chalk, flints, Lias limestone and shale, and quartzite) passing into lighter coloured loam with smaller stones and broken flints.

Ringsfield.—A pit, a quarter of a mile south-east of the church, showed 5 feet of Boulder Clay resting on about 20 feet of false-bedded sand and gravel.

Beccles.—A quarter of a mile east of Ingate Mill the following section was exposed (*see also* p. 133) :—

	FEET.
Gravel, sand, and chalky Boulder Clay very irregular (with *Elephas primigenius*) - - - - - - - -	6
Rather fine pebbly beds with a few large unworn flints - -	12+

At the brick-yard, near Wash Lane Farm, the following beds were shown :—

	FEET.
About 6 feet of whitish chalky Boulder Clay without many large stones, resting on sand and gravelly loam apparently contorted - - - - - - - - -	6
Fine white sand - - - - - - - -	2 to 4
Bright orange sand, with small stones, mostly angular - -	2+

At the N. end of the sand-pit, on Bonaparte's Island, 4 feet of chalky Boulder Clay was shown, apparently plunging under the alluvium.

The Pot Yard, Beccles, showed the following section :—

	FEET.
Soil - - - - - - - - -	2
Yellow clayey brick earth - - - - -	3
Stiff blue clay with chalk, a few angular flints, Lias, &c., nearly all scratched - - - - - - -	12+

CLEMENT REID.

E. Gravel ("Cannon Shot" Gravel).

Forming portions of the higher ground in the district are deposits of coarse flint gravel, which from their nature, position, or supposed origin, have been spoken of as the Cannon-shot gravel, Plateau gravel, and Flood gravel.

As Mr. Wood, jun., classified everything newer than the chalky Boulder Clay as Post-glacial, he has grouped these gravels (although with some doubt) as older Post-glacial. They are, however, intimately connected with the Boulder Clay.

They can be traced, more often by general position than in actual section, above the chalky Boulder Clay, but at Tharston Furze Hill, in the deep road-cutting by Wymondham Station

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(Quarter Sheet, 66 S.W.), and in many places in West Norfolk, they have been shown in section together; the gravel on the Boulder Clay. In the parish of Ashwell Thorpe, south of Wrenningham, there is a pit in coarse gravel which was shown in excavations on the new line of railway to underlie the Boulder Clay.

These gravels are made up for the most part of large boulders of flint, and even paramoudras, whose battered surfaces indicate that they have been knocked about very considerably, and suggest analogous formation to the coarse flint beaches near Runton. They, however, occupy a higher level than does the Chalk, and only in a few places in the area (Hapton, Tasburgh, Tharston Furze Hill) do the beds erode through other deposits so as to rest directly on the Chalk. They attain a thickness of 45 feet.

Besides flint boulders, are many pebbles of flint, and sometimes of chalk, pea-like grains and pebbles of quartz and quartzite, and occasional boulders of sandstone, grit, quartz, and various igneous rocks. Often presenting no regular lines of stratification, it seems to be a tumultuous deposit. No fossils of the period have been met with in it. And, so far as can be judged, these deposits are most likely flood gravels of the Glacial period, due in part to the melting back of the ice-sheet which produced the chalky Boulder Clay, and in part to land-floods caused by excessive rain.* It seems to me probable that the agent which brought the coarse gravels, marked out some of the main outlines of the present drainage systems, for they in places border the valleys and even descend into them† (*see* pp. 25, 146).

The gravels are largely dug for mending roads, and some of the large flint boulders are used for building, and even for paving some of the streets of Norwich, where, under the name of "cobbles" or "petrified kidneys," they form excellent stumbling blocks both for man and beast.

S. Woodward, in his "Observations on the Round Towers of Norfolk," noticed that, with one exception (West Dereham), all these churches were built of flint boulders, and he stated his conviction that they owed their form, not to any peculiar style, but had been built from necessity, in consequence of the absence of freestone from the soil.‡

Local Details.

Strumpshaw.—The little outlier of gravel that caps, and, indeed, forms Strumpshaw Hill, possesses in itself one of the most striking and extensive gravel pits in the country, and from the numerous old excavations it must have been worked for many a year. Indeed, situated as it is in a clay district, it has furnished and still furnishes road-material to a number of parishes.

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* *See* Dr. J. Geikie, Great Ice Age, edit. 2., p. 385; S. B. J. Skertchly, Geology of the Fenland, p. 196.

† H. B. W., Proc. Norwich Geol. Soc., vol. i., p. 63; *see also* S. V. Wood, junior, Quart. Journ. Geol. Soc., vol. xxxvi., p. 501.

‡ Archæologia, vol. xxxiii., p. 7. The opinion is adopted by J. H. Parker, Glossary of Architecture, new ed., 1866, p. 278.

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As much as 45 feet of boulder gravel, shingle, and sand was shown in the pit immediately west of the mill. The gravel itself was considerably "faulted," as shown by included beds of sand in the coarse gravel; but this might have been due to the thawing of masses of ice, originally buried up in these torrential deposits of gravel. In one place there was an included mass of chalky clay with brown shaly clay on top of it. Strange to say, many writers have spoken of Strumpshaw Hill as composed of "blue clay," this, however, must refer to the Boulder Clay which underlies the gravel, unless some included mass of economic value was at one time exposed (*see* p. 114).

In a pit a little south-east of the mill, the surface soil had been cleared off the gravel, and, as observed by Mr. Skertchly, the latter was grooved in a direction N.W. and S.E.

Moulton.—"A small gravel and sand pit occurs in a field, 200 yards S.E. of the church. Reddish-brown sand, with a little coarse gravel and brown loam, together about 6 feet thick, is shown overlying chalky Boulder Clay. The sand is very ferruginous and occasionally slightly indurated. This small patch of gravel and sand is apparently situated on the highest ground in the immediate vicinity."*

Norwich.—On Mousehold Heath there is a thick capping of the coarse gravel here and there. In the pit by the *M* of Mousehold Heath (on the map) there is 5 or 6 feet of it. But it is difficult to trace any line of distinction between it and the finer gravelly sands which are often conspicuously stratified. Such is the case in the brickyard and gravel pit on the Plumstead road, near Kett's Castle (*see* p. 98; and Fig. 3, Plate II.).

Higher up, in Moore's pit, the gravel must attain a thickness of quite 25 feet; and comprises beds of very coarse boulder gravel and sand, with sometimes loamy beds.

Newman's pit, by the mill on the Plumstead road, showed 12 feet of the Boulder Gravel, resting on 5 feet 6 inches of gravel and sand, not so coarse.

Near the surface the boulders were often decayed so that they were shattered or broke in pieces when dropped.

In these pits every variety of gravel can be obtained by means of numerous sieves; fine quartz pebbles are obtained for the use of brewers in cleaning vats, and the boulders are in demand for building purposes and for paving.

The surface of Mousehold is covered with excavations, some of which have been thought to be early British pit-dwellings; similar pits have been remarked at Eaton.†

Taverham.—North-east of Spring Farm a pit showed angular flint gravel.

Costessey, &c.—Costessey Old Hall is situated on a coarse gravel, and half a mile to the west a pit showed 15 feet of it.

Between Bauburgh and Little Melton the sand seems to overlie the Boulder Clay; and very likely, as at Cringleford, the Boulder Clay may wedge into the sand, so as to rest on sand, and be overlaid by it.

Colney.—At the north-west corner of Beck Pease plantation, a pit showed buff sand with chalk grains resting on the pebbly gravel. South of the plantation and of the high road, a pit showed 7 feet of sand with angular fragments of flint and iron-sandstone.

West of Cringleford the boundary of Boulder Clay and sand is very difficult to trace, and I am disposed to think that they are intercalated together as seen in the pit near Keswick, at Wymondham Station and elsewhere.

Hethersett,‡ Ketteringham, &c.—Gravel and sand rest on the Boulder Clay here. At the Dairy Farm there is 5 or 6 feet of coarse angular gravel and buff sand, and in Ketteringham Park 12 feet of coarse gravel was opened up to the east of the Hall.

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* From Mr. J. H. Blake's notes.

† E. King, Munimenta Antiqua, p. 52; H. Harrod, Norf. Archæol., vol. iii., p. 232.

‡ South of Thickthorn, the topography on the map is much cramped up.

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Hethersett Church rests on a sandy soil overlying the chalky Boulder Clay, and this soil obscures much of the ground to the south of the Railway Station and Cantley White House.

About 3 furlongs to the north of the Station, and east of the road, a large pit showed the following beds, which partly occupy a basin in the chalky Boulder Clay (*see* Fig. 19, Plate VII.), :—

	Feet.
i. Soil (warp and mould)	3 to 4
h. Angular and rolled gravel	4 to 6
g. Coarse buff and brown sand	
f. Angular and rolled gravel and sand	5
e. Sand	1 to 6½
d. Gravel	6 to 8
c. Very coarse boulder gravel and finer gravel with included bed of sand	3 to 4
b. Buff sand, with seams of chalky sand	3
a. Coarse gravel (base not seen)	6

Immediately west of the station the cuttings showed 8 feet of buff false-bedded sand, overlaid by a thin gravelly soil, and, further on, this sand is capped by brown loam and chalky gravel. East of Ketteringham Bridge the cutting showed sand and brickearth with chalk stones, much disturbed, resting on chalky Boulder Clay.

East of Dogkennel Meadow the gravel is apparently replaced by 6 feet of stony and sandy loam. This may be the same as a bed of brickearth formerly worked south-west of Intwood Hall.

At East Carlton, and east of the Lodge, Mulbarton, the gravel and sand (15 feet) rest on the Boulder Clay; so also south of Swainsthorpe Station (8 feet), and east of Wrenningham Mill, sections of gravel may be seen.

Markshall.—*See* p. 72.

Ashwell Thorpe.—Half a mile south-west of Wrenningham Church a large pit showed the following section :—

Glacial Drift	Coarse flint gravel with sandy seams marking rough bedding	12 ft.
	Sand	6 to 8 in.
	Clay, even line	
	Chalky gravel, sandy, and with flints	1 to 4 ft.
Upper Crag	Buff and brown sands and fine gravel.	

To the south-east the gravel passes under the Boulder Clay.

Forncett St. Peter.—South of the church 6 feet of rough flint gravel, with pebbles of quartz and quartzite, has been worked.

Hapton.—A large ballast-pit by the railway east of Hapton Hall showed 30 feet (base not seen) of coarse gravel, interstratified with beds and lenticular patches of sand. It is made up of flint, quartz, and quartzite, with some chalk pebbles.

South-east of the Hall is a pit showing the gravel resting on the chalky Boulder Clay. It contains septaria.

East of Hapton Hole there is 20 to 25 feet of coarse flint gravel, roughly stratified with beds of buff and yellow sand; and W.N.W. of this place are two outliers in the more easterly of which 3 feet of coarse gravel was exposed in a pit.

Tharston, &c.—At Furze Hill the coarse gravel rests on the laminated series and pebbly gravel, with, in one part of the pit, a patch of chalky Boulder Clay.

Mr. S. V. Wood, jun., in referring to this pit, described it as gravel "in "which long bands (some 30 yards) of Upper Glacial Clay occur intermixed "with the gravel, indicative of the severe conditions during this early "period."* At the time of my visits the Boulder Clay was well shown in an isolated mass underlying the coarse gravel and resting on the Crag series (*see*

* MS. Memoir in Geol. Soc., p. 41.

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Fig. 10, Plate III.). In the glacial gravel was a large rounded mass of coarse grit, a little more than 3 feet broad by 1 foot in thickness. Boulders of flint, quartz, and quartzite were not uncommon (*see* p. 69).

From Hapton, Tharston, and Tasburgh the coarse gravel stretches down into the valley, even to the borders of the Alluvium.

It may be seen south of the Roman Camp at Tasburgh (12 feet), and in the parish of Mourning Thorpe, south of the gravel-pit plantation (18 feet). Outliers also occur at Hempnall, but to the north-east of the church the gravel has been almost entirely worked away.

Woodton, Hedenham, &c.—South-east of Woodton church are patches of coarse unstratified ferruginous flint gravel, which have been mapped by Mr. Reid. Other outliers of this gravel occur in the valley, at Hedenham (*see* p. 114) and Ditchingham. These deposits he has grouped as River-gravel, because they appear to be closely connected with the valley-gravel of Bungay and Ellingham. It may be, however, that they belong to the Upper Glacial Gravel, and were deposited at the close of that cold period of which the chalky Boulder Clay is a witness. In this case they may be merely the earliest Alluvial deposits of the valleys whose excavation was commenced when the rigours of the last great glaciation of the district were passing away (*see* p. 129).

Shottesham St. Mary.—Sheets Hill is capped by gravel of varying thickness and character, which is well shown in a large pit marked on the map (*see* p. 104).

This shows in one part:—

Rudely stratified coarse gravel and sand, with a vein of chalky gravel - - - - -	15 to 20 feet
Coarse gravel, made up chiefly of flint boulders -	12 to 15 „

Another part of the pit showed:—

Fine stratified gravel and sand - - -	6 to 8 feet.
Buff laminated brickearth - - - -	10 inches.
Chalk gravel with a few large flints - - -	3 feet.

The relation of the gravel to the Boulder Clay was by no means clear, the pits of gravel and clay adjoining, and yet neither deposit showed above or below the other.

Poringland.—In the straggling outlier of Poringland, reddish-brown boulder gravel is exposed by the Railway Tavern (18 feet).

Framingham Pigot.—East of Bixley plantation the gravel is well shown to a depth of 20 feet. It is rudely stratified, the bedding being marked by layers of sand and pebbles. At one part of the pit a mass of sand and gravel was let into the midst of coarse gravel, as if faulted, but there were no signs of displacement beneath. The gravel here is in places cemented into a hard conglomerate or iron-pan. This is also the case at Blackford Hall, where 20 feet of well stratified sand and coarse gravel was exposed.

Brooke, &c.—In a large pit near Brooke Farm 25 feet of gravel and sand is shown. In places this is highly inclined (from 20° to 30°), and altogether it is very variable in nature, at one place showing rude bedding, in another no traces of it whatever. The western portion of this outlier, in Howe parish, showed 12 feet of sand and gravel, some of it very pebbly, other portions coarse. South-east of Brooke Hall 10 feet of coarse gravel and sand was exposed.

Sand occurs on the Boulder Clay at Surlingham St. Saviour Church, also half a mile S.E. of Surlingham St. Mary.

Thurton.—Fifteen feet of buff sand rests on the Boulder Clay by the church.

Chedgrave.—North-east of the Manor House a pit showed 3 to 6 feet of gravel and sand, resting on the chalky Boulder Clay, and this again on buff sand.

Seething.—By the Hall and at Swan's Grove there is much sand over the chalky Boulder Clay.

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Sizeland.—By the windmill there is irregular gravel and buff and white chalky sand resting on the Boulder Clay.

Beccles.—"A quarter of a mile east of Ingate Mill there was opened up an "irregular mixture of gravel, sand, beds of chalk-pebbles, and different "coloured clays, about 7 feet in thickness. Portion of a tooth of *Elephas* "*primigenius*, obtained from this pit, is preserved in the collection of Mr. W. M. "Crowfoot, at Beccles. The deposit itself is grouped with the Upper Glacial, "but it might belong to the Lower Glacial Drift." *

"The Boulder Clay fills a deep hollow along the railway at Ingate, the east bank of which, eroded in the Chillesford beds, is very precipitous. Small patches occur on the north side of the churchyard and between the Waveney Valley and Beccles Fen. Half a mile E. by S. of Castle Farm, the following section was to be seen by the roadside :—

	Feet.
Blue Boulder Clay.	
Red, jointed Boulder Clay - - - - -	2
Clayey sand with streaks of Boulder Clay - - -	3
White sand." †	

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* From Mr. Reid's notes.
† From Mr. W. H. Dalton's notes.

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CHAPTER VI.—SURFACE PHENOMENA.

Disturbed Chalk.

The Chalk where exposed at the surface in the valleys of the Yare and the Wensum, not unfrequently shows signs of disturbance. Thus the flint-layers are broken up, sand and stones are introduced, and the Chalk itself presents a rubbly appearance, to a depth of from 1 to 8 feet, and sometimes more.

This disturbed Chalk is often spoken of as the "Glaciated Chalk," or "Chalk Marl;" it passes gradually down into the undisturbed Chalk beneath. "Pipes" are abundant in it, and at Trowse it is burnt for lime, being considered to furnish better material than the undisturbed Chalk.

This disturbed Chalk may be seen in a pit north of Taverham Church, and in another to the south-east of the church; in pits east and north-west of Drayton; north-east of Earlham Parsonage; at Cringleford, north of the letter *d* of Cringleford Hall (on the map), and near Oakland House, the residence of Mr. F. W. Harmer; near Keswick Church; north of Chapel Hill; and in a pit about half a mile south-east of Tasburgh Church.

One of the most interesting sections is exposed on the western side of the large pit at Hartford Bridge. Here the disturbed surface of the Chalk is generally admitted to be due to glacial action; the Rev. O. Fisher attributes it to the action of stranding icebergs,* but I am disposed to refer it to the direct influence of land-ice (*see* p. 137).

The section at Hartford Bridge was as follows:—

	Feet.
Warp - - - - - - - -	2
Contorted chalky débris and sand with pebbles, "dead lime"	7
Chalk much broken up - - - - - -	9
Chalk (undisturbed).	

When the meeting of the British Association was held at Norwich in 1868 special attention was called by Mr. J. E. Taylor to a remarkable "saddle-shaped" disturbance that was opened up in the Chalk at Whitlingham. Here the beds, with conspicuous bands of flint, were so bent up as to form an acute angle, which was very well defined. Mr. Taylor maintained that this disturbance, which was quite local, was produced by glacial action, and that the immediate cause was the grounding of an iceberg,†

Another disturbance to which Mr. Taylor called attention (in 1866) was to be seen in a chalk pit at Swainsthorpe; his description I now quote. "On the left side (of the pit) the flint bands "are nearly perpendicular, being somewhat contorted and leaning

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* Geol. Mag. vol. v., pp. 551, 552.

† The section was first described by Mr. Taylor in 1865, at which time he was of opinion that the disturbance took place before the time of the Norwich Crag.—Geol. Mag., vol. ii., p. 324. *See also* his paper "On certain Phenomena in the Drift near Norwich."—*Ibid.*, vol. vi., p. 508. An illustration of the pit, reduced from a photograph, is given in my Geology of England and Wales, p. 287.

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"towards the right. On the right side the bands are perhaps "more perpendicular still, but lean towards the left. The con- "torted bands, indeed, are but the flanks of an anticlinal arch, "the summit of which has been denuded * * * The flint "bands are shattered and broken as though by the influence of "some sudden force." In a subsequent paper, Mr. Taylor, after pointing out the proximity of the Boulder clay, says, "Close by "the patch of Boulder clay at Swainsthorpe, and on the same "general level, the re-deposited Chalk crops up, and the flint "bands may be seen contorted and dragged up into an angle of "nearly 60°."*

Subsequently Mr. T. G. Bayfield communicated to the Norwich Geological Society the fact that a somewhat similar disturbance was to be seen in the Chalk at Trowse, situated about a mile and a half from the pit at Whitlingham, and on a continuation of the same range of low hills bordering the river Yare.

On visiting this section at Trowse in October 1875, it presented the main features depicted in the accompanying diagram (fig. 24, Plate VIII.), the north-western corner of the pit only being then not free from talus. The Chalk, with layers of flints and paramoudras *in situ* (A), was seen to be inclined at an angle of from 35° to 40° in a south-easterly direction. Above it were sand with pebbly seams (E) and laminated clay (D), containing a few shells: and these beds in point of structure and organic remains evidently belonged to the Norwich Crag. Resting irregularly upon them were coarse gravel (F) and sand (G), and brown clay (H), all of which were most likely Glacial Drift.

At the time I thought that a deep-seated anticlinal disturbance, resulting in a fault, was probably the explanation of the inclined strata both at Trowse and Whitlingham; although this view was combated by Mr. Harmer, who considered that the disturbances were of glacial origin.† From time to time I revisited the pit, and having meanwhile traced the chalky Boulder Clay over the higher ground above it, and in another pit further south, directly on to the Chalk, I looked more attentively at the chalky soil on the western side of the pit in question, to see if it presented any traces of this glacial deposit. Here I was much surprised to find that portions of what I had hitherto taken to be Chalk *in situ* consisted of a re-constructed mass of this material, of a rubbly or brecciated nature, and somewhat sandy, which passed up into beds much like some varieties of the chalky Boulder Clay.

On another visit paid in company with Mr. S. W. Utting and Mr. Clement Reid, the northern extremity of the pit had been entirely cleared, and what there appeared at a glance to be bedded chalk was found to pass up into sandy and marly beds, and itself to contain not only fractured flints, but pebbles of flint, quartz, and quartzite. These pebbles and also the broken flints were dispersed through the mass of the strata, as was proved not merely by the newly exposed surfaces in the pit, but by the evidence furnished in two galleries made 15 or 20 feet into the beds. One of these was driven under the uptilted mass of Chalk with flints, and showed that this re-arranged Chalk with pebbles actually occurred beneath the beds upraised from their natural position.

More recently still a pit about 20 feet deep, excavated beneath the usual level of the roadway, showed that the flint layers gradually assumed a horizontal position in descending; and also exposed the remarkable section, Fig. 25, which is cut into the side of the pit about 20 yards nearer the entrance than the section Fig. 24. This intersects the beds in a similar direction to the other

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* Geol. Mag., vol. iii., p. 44; vi., p. 509.

† Some local flexures in the Chalk near Royston, caused by subterranean disturbance, have been lately described by Messrs. W. Whitaker and W. H. Penning. See explanation of Sheet 47 of the Geol. Survey Map, pp. 8, 11.

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opening, and shows the tongue of reconstructed material forced under the disturbed Chalk (B). The sandy pockets (C) are also interesting, as being similar to those noticed in the disturbed Chalk of Trimmingham by the Rev. O. Fisher, and attributed by Mr. Reid "to the sharp folding of the Chalk, causing "irregular cavities to open."*

This settled the question that the inclination of the flint-layers was not produced by subterranean disturbance, but by a force acting on the surface. Such a force was sufficiently powerful and sustained to grind up the Chalk and fracture its flints. The Chalk was probably reduced to a soft mud through which the pebbles may have sunk: afterwards the mass became consolidated or "set" like mortar. The rude bedding may (like that occasionally seen in the chalky Boulder Clay) have been produced by one layer being forced over another at the time of its formation, or it may have originated subsequently. So much does it resemble the ordinary Chalk that many who have visited the pit with me, have not been easily convinced that it was not so; nor were those members of the Geologists' Association, who saw the pit on Whit-Monday, 1878, altogether devoid of scepticism, though in the end I believe all went away convinced.†

From the fact that beds of the age of the Norwich Crag are disturbed together with the Chalk, it may be concluded that they were forced up in Post-Pliocene times; and from the relation borne by the chalky Boulder Clay to the Chalk in this immediate neighbourhood, and in many pits around Norwich, I feel no hesitation in concluding that the disturbance was produced by the agent which formed this Boulder Clay.

Without entering upon a general discussion of the origin of this Glacial deposit, I may state my opinion in favour of the views advocated by Dr. James Geikie and Mr. S. B. J. Skertchly, that it was the direct product of land-ice.‡ So far as I have observed, it presents no signs of deposition under water, and it not unfrequently disturbs and contorts the beds it overlies. I cannot conceive how a grounding iceberg could have produced the disturbance at Trowse; but the slow and continuous grinding action of an ice sheet, acting perhaps on some inequality of the ground, might I think have caused it, and this view gains support when we take into consideration the other disturbances and contortions in the district.

The chalk pit to the north-east of this Trowse pit shows the Chalk-with-flints undisturbed, capped by a loamy soil, with here and there marly patches like chalky Boulder Clay.

The disturbance at Whitlingham was very local. A gentle anticlinal was shown in the pit adjoining on the west. The beds which it affected have now been almost quarried away; but the fold took a north-easterly and south-westerly direction which roughly corresponds with the strike of the beds at Trowse: thus in both cases pointing to a force from the north-west.

Mr. R. Fitch has stated that a somewhat similar disturbance in the Chalk was at one time visible at Postwick,§ and Messrs Wood and Harmer have drawn attention to many other instances of "glaciated chalk."‖

In 1866 Mr. Wood brought before this Society evidence of what he then considered to be land-glaciation during the earlier part of the glacial period in England.¶ This was seen in a section at Litcham, where the Chalk for a distance of 15 or 20 feet from the surface was disturbed "by a force acting "*downwards from the surface*, and becoming less powerful the deeper the "section descends." And Mr. Wood concluded that "we have here evidence

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* Geol. Mag., Dec. II., vol. vii., pp. 148, 238.
† An account of this excursion is given in the Proc. Geol. Assoc., vol. v., p. 513.
‡ Great Ice Age, 2nd ed., p. 253.
§ Norwich Geol. Soc., Norwich Mercury, March 7, 1868.
‖ Quart. Journ. Geol. Soc., vol. xxxiii., p. 88.
¶ *Idem*, vol. xxiii., p. 86.

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" of the passage of a glacier* over the surface of the chalk." What is of much additional interest is contained in the following passage (p. 87). " Con- " necting this section with the masses seen in the contorted portion of the " lower [contorted] drift on the coast section, we seem to see the process under " which these masses were dragged from their matrix, and carried onward to " the sound into which the glacier disembogued."

Although Mr. Wood at first attributed this disturbance at Litcham to the period of the lower drift, to which period Mr. J. E. Taylor assigned the glaciated chalk, yet he subsequently referred it to the age of the chalky Boulder Clay.† In the disturbed strata at Trowse we have a similar instance of the incipient formation of a huge chalk boulder. And from my experience in the neighbourhood of Norwich I have come to the conclusion that while many of the contortions seen in the strata—whether Chalk, Crag, or lower Glacial—are clearly due to the agent which brought the Boulder Clay; of the numerous cases where this positive evidence is wanting, I know of no instance where the contortion might not have been produced at this same period.

In the neighourhood of Norwich the disturbed or glaciated chalk is seen in the pits bordering the rivers. And the fact of its frequent occurrence in such situations has led Messrs. Wood and Harmer to conclude that the valleys were to a large extent, if not mainly, excavated by glacial action. Although the glaciated chalk is frequently shown in the valleys of the Yare and Wensum, yet I can not go so far as to say this proves that the valleys were excavated by glacial action. In every case such glaciation *can* be connected with the chalky Boulder Clay, and was I think produced by the immediate erosion of the Chalk by the agent which produced the clay; just as near Brandon, as pointed out to me by Mr. Skertchly, it has overridden the Chalk and often left only a contorted marly surface deposit called "dead lime" to mark its former presence above the Chalk. This "dead lime" he identified in the pit near Hartford Bridge (*see* p. 134). And what is "dead lime" on the chalk is contorted sand or clay on newer formations over which the Boulder Clay has been pushed. The Boulder Clay, from its uniform character and present wide distribution, no doubt covered a large extent of country, a plain of lower glacial and older strata, which it levelled up; in some cases the agent to which it was due eroding along certain lines, in others perhaps filling original valleys; but the exposure of glaciated chalk along the lines of the present valleys no more proves that they were excavated by glacial action, than does the occurrence of the Crag in the valleys indicate their former occupation by the sea. The appearance of glaciated chalk in the valleys is due to the fact that old grooves or lines of previous erosion have been re-excavated here and there.‡

It has been hinted that the disturbance at Trowse might have been due to the ice having acted on some irregularity in the ground, impinging perhaps on an old cliff which formed a local bar. This would necessitate belief in some interglacial denudation, and such denudation is indicated by the generally unconformable relations of the chalky Boulder Clay to the deposits upon which it rests.

In connection with this subject is the interesting fact that Mammalian remains have been found in this disturbed Chalk in several localities. About the middle of last century Mr. H. Baker recorded,§ "Part of the horn and " palm of a deer, found in a chalk pit at a village called Baber [Banburgh], 4 " miles E. of Norwich, at the depth of 16 feet, and almost converted into a " chalky substance." This, like other specimens found in similar positions, evidently appeared from its mineralization as if it were a true chalk fossil. The discovery of deer's horns at Whitlingham was mentioned about the same

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* Mr. Wood states that in speaking of a glacier, he refers to one enveloping the whole surface of the country, as described by Dr. Sutherland, Quart. Journ. Geol. Soc., vol. ix., p. 301.

† Geol. Mag., Dec. II., vol. iv., p. 486.

‡ *See* H. B. W., Address, Proc. Norwich Geol. Soc., vol. i., pp. 60, 63.

§ Phil. Trans., abridged by Martyn, vol. x., p. 601.

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date by Arderon,* and subsequently confirmed by S. Woodward, who noticed their occurrence in the disturbed Chalk both here and at Sprowston.† Since these records the late J. W. Ewing, Mr. Fitch, and Mr. Bayfield have brought many specimens, including shed antlers, under the notice of the Norwich Geological Society. These include the mammoth, the red deer, and another species like the roe deer; while the localities of Thorpe near Norwich, Hartford Bridge, Markshall, and Eaton have been added to the list.

Elephas primigenius has been found in the cutting below the viaduct near Hartford Bridge,‡ and in "Chalk rubble, Norwich,"§ while antlers of deer have been found at Norwich,‖ Trowse or Lakenham, Markshall, Eaton, and Whitlingham.

At a meeting of the Norwich Geological Society held on March 4, 1868, Mr. J. W. Ewing exhibited several portions of antlers, which he had obtained from a pit in his grounds at Eaton. The animal remains were found in the rubble or disturbed Chalk. The remains included shed horns as well as others.¶ Commenting on this discovery Mr. Gunn said he was "struck with "the marks of cutting and abrasion by some blunt instrument on the pedicle "of one specimen of the red deer, and of sawing upon another."** A stone implement was said to have been found with the bones of deer, but its character was not described.

Arderon stated also that "the entire skeleton of a man was found in the "same bed or stratum, with the above-mentioned horns." It is probable that not only was there Chalk disturbed by glacial agency, but Chalk disturbed by human agency. Canon Greenwell†† has even suggested that the Cervine remains might have been introduced artificially, regarding the antlers as similar to those met with at Grime's Graves, near Brandon, and which were used as picks by the flint-workers; for they present a similar mineralization.

The Rev. O. Fisher,‡‡ who regarded the Chalk as "disintegrated *in situ* by the percolation of atmospheric water," has suggested that the Cervine remains might be of the age of the Forest Bed; but the occurrence of the Mammoth is strong evidence that they belong to a later period, and they may be assigned to the interval between the formation of the Lower Glacial brickearth and sand and the Upper (Chalky) Boulder Clay in Norfolk. In other words they may belong to the period of inter-glacial denudation just now suggested, to which period probably belong the Brandon Beds described by my colleague Mr. Skertchly. (*See* p. 110.)

Pipes in the Chalk and other Deposits.

The surface of the Chalk is well-known to be almost everywhere much indented or furrowed, a feature due to the solvent action of water holding carbonic acid, and to the mechanical abrasion which running water must exercise.

These irregularities, termed "sand galls" or "pipes," are usually filled with the deposit that immediately overlies the Chalk. The material is generally sand and gravel, with a few entire flints, and some clay; in fact the method of formation of the pipes requires a porous stratum, and we find that where clay or brickearth rests immediately upon the Chalk, pipes are rarely found, and

* Phil. Trans., vol. xliv., p. 275.
† Geology of Norfolk, p. 50; *see also* R. C. Taylor, Geol. E. Norfolk, p. 15.
‡ Meeting of Norwich Geol. Soc., July 14, 1871; report in Norfolk News, July.
§ Specimen in Norwich Museum; another specimen is simply labelled "Norfolk."
‖ Specimens in Norwich Museum.
¶ Norwich Mercury, March 7, 1868.
** *Ibid.*, June 1868. *See* also R. Fitch, Norfolk News, June 11, 1870.
†† Journ. Ethnol. Soc., vol. ii., Jan. 1871.
‡‡ Geol. Mag., vol. v., p. 551.

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then only where they contain the remnants of an earlier deposit which they have thus preserved.

In a Chalk pit at Stoke Holy Cross I noticed that where patches of laminated clay occurred the Chalk was not piped, and where absent it was piped.

It might have been expected that traces of Eocene beds would have been detected in some of the old pipes in the Chalk. Mr. Gunn remarked on this subject many years ago,* but no such discovery has yet been made.

A pipe at the large Chalk pit north-west of Drayton extended to a depth of nearly 20 feet with a breadth of about 5 feet; and a large pipe having a diameter of nearly 40 feet is mentioned as having been seen in the Chalk at Coltishall.†

Subsidences of the land are occasionally produced by the falling of the earth into one of these pipes. Arderon described a sinking of the land at Horsford, where a circular hole, 12 feet deep and 12½ feet in diameter, was produced.‡ This happened at night time during a violent thunderstorm, the rain no doubt loosening the soil. The hole exposed :—

		Feet.
Glacial Drift.	Corn mould earth - - -	3
Upper Crag?	Brown and yellow sand - -	9

Cavities in the Chalk sometimes remain unfilled with earth, and they generally become reservoirs of water. Mr. O. Fisher says, "The workmen at Horstead Chalk-pit in Norfolk (where "the Chalk is wrought beneath a thick covering of Norwich "Crag) assured me that they occasionally came upon hollow "pipes, roofed over by the 'uncallow,' *i.e.*, the Crag deposits. "This is quite probable, on account of the firmly compacted bed of "great flints which immediately cover the Chalk."§

Mr. A. W. Morant mentions that—"The farm at Whitlingham, "upon which the sewage of Norwich is pumped, has for subsoil "the sands forming the strata known as the Norwich Crag, "which lies immediately upon the Chalk, having a depth, I "think, of 30 feet or 40 feet. When the sewage was first allowed "to flow over the land, we were astonished day by day to find "the fields to be soon covered with circular holes, usually about "3 feet, 4 feet, or 5 feet in diameter and of various depths, the "side always being vertical; on one occasion the ground suddenly "subsided for a space of 21 feet in diameter and to a depth of "12 feet. The sections of the Chalk in pits in the neighbourhood "show that the surface has numerous holes, which are known as "'sand galls' or 'sand pipes,' and it appeared probable that the "subsidence had taken place in these holes on account of the "large quantity of water flowing over and working into the land

* Proc. Geol. Soc., vol. iii., p. 170 (1840).
† Taylor and Morant, Geol. Mag., vol. vii., p. 121.
‡ Phil. Trans., xliii., p. 528 (1746).
§ Geol. Mag., vol. ii., p. 102.

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"so far in excess of any rainfall the soil had previously been "exposed to."*

Occasional subsidences are likewise produced by the falling or "caving" in of the strata into the artificial workings in the Chalk.† (*See* pp. 9, 28.)

In places where the Chalk has been disturbed by glacial action, pipes are likewise met with, and they are very frequently seen on the surface of the chalky Boulder Clay,‡ or of marl-masses in the Contorted Drift.

Pipes have been noticed in the Norwich Crag where the shell-beds are well developed, a feature common in the Red and Coralline Crags in Suffolk. They have been spoken of "as so many natural drains."§

Pipes having a sloping direction from the face of a pit, when exposed, appear more or less circular. Such an instance was to be seen at one time near the base of the Chalk exposed in the St. James' pit.

Among instances of the more irregular dissolution and erosion of the Chalk, may be noted the section near Keswick Mill, shown in Fig. 23, Plate VIII. Here the Chalk (A) is overlaid by coarse and fine gravel and sand, 8 or 10 feet in thickness (B), and by chalky gravel and rubble (C).

Another section by the river south-east of the Mill, Stoke Holy Cross, showed chalky and gravelly soil resting on the Chalk, which was broken and crumbly, and deeply eroded.

In describing the contents of some of the pipes or sand-galls in the Chalk at Eaton, Lyell observed that "the fine yellow clay "at the bottom of some of the pipes has been found by Mr. "Colkett, of Norwich, to make a good oil paint of a colour "between raw sienna and Roman ochre."

He believed that the clay, which often lines the pipes, was left on the sides of the hollows by the waters that had formed them, and that it was an insoluble residue from the White Chalk itself.‖ In this respect it would be analogous to the Clay-with-flints of Hertfordshire, Buckinghamshire, &c.

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* Engineer, vol. li., p. 123. *See also* remarks by T. V. Holmes, Report, Lewisham and Blackheath Assoc., July 1881, p. 23.

† Nall in his Glossary of the Dialect and Provincialisms of East Anglia (1866) gives—*Cave in* : to give way at the edge, to fall into a hollow below.

‡ *See* J. Trimmer, Quart. Journ. Geol. Soc., vol. x., p. 237.

§ *See* Taylor and Morant, Geol. Mag., vol. vii., p. 120.

‖ Phil. Mag., 1839, p. 258. Pipes at Heigham, Hellesdon, and Thorpe are also described. *See* also Elements of Geology, 6th edit., pp. 82, 83, and W. Whitaker, Mem. Geol. Survey, vol. iv., p. 57.

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CHAPTER VII.—ALLUVIAL DEPOSITS.

The Alluvium consists of silt or mud, clay, loam, sand, gravel, and peat, forming the marshland, and the level meadows bordering the rivers; tracts which, as a rule, are conspicuously marked off from the bordering hills.

Islets or insulated plots of rising ground in the Alluvium are called "Holms" or "Holmes."* One of these is met with near Bistley, south-east of Neatishead, and upon another the Abbey of St. Benedict (sometimes called St. Benet Holme) was placed. In the old parish of St. Vedast or St. Faith in Norwich (long since abolished) there was formerly an island in the river called the "Swan Bank," and also several "bitmays," or pieces of land gained out of the river, which paid small rents to the city.†

The Alluvial districts constitute most of the permanent pasture, where cattle introduced from various parts of the country, from Ireland and abroad, are put to graze. Plantations of osiers and alders, called "Cars," are frequent along the borders of the rivers. The common reed (*Arundo phragmites*) grows extensively around the Broads, and is much used for thatching.

Peat has been extensively dug in several places in the area, but very little is procured now.

In a few places earth suitable for brickmaking has been obtained from the Alluvium. Mr. Blake has informed me, that to the south-east of Haddiscoe Church, bricks have been made from an alluvial brickearth.

There are no very extensive deposits of Valley gravel in the area, nor are those present noted, as in other parts of the Eastern Counties, for the occurrence of flint implements or extinct mammalia. The gravel, as a rule, is a coarse subangular flint-gravel.

Waveney Valley.

Mr. C. Reid has mapped several areas of Valley gravel at Earsham, Bungay, Ditchingham, and Ellingham (*see* p. 132). The following notes are his:—

At Ellingham railway-station the cutting showed 15 feet of ferruginous gravel, with a few beds of sand. A boar's tusk was found near the bottom of it. Irregular chalky clay was seen beneath the gravel, and beneath that, sand.

The pits above Aldeby brickyard show fine false-bedded gravel and sand, resting on gravel with boulders of grit. South-west of the pit, about 3 furlongs distant, about 20 feet of Valley gravel (?) was to be seen.

Above the G of Gaol (on the map) at Beccles, 15 feet of Valley gravel was opened up.

C. Reid.

Yare Valley.

A very fine section of Valley gravel is exposed at the Thorpe Station, Norwich. There, as elsewhere, the gravel is almost entirely made up of the older Pliocene and Glacial gravels, some few flints only being perhaps directly

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* An Anglo-Saxon and Norse term for a small island. *See* Robberds, Geol. E. Norf., pp. 4, 35.

† Blomefield, 8vo edit., vol. ii., p. 106.

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derived from the Chalk. Hence it may be regarded more properly as the accumulation rather than the formation of the river.

In composition it shows subangular flints and pebbles of flint, quartz, and quartzite; it is roughly stratified with beds of sand.

In Norwich the Cathedral is placed on the Valley gravel; and by Kett's slab, St. Martin's at Palace, 4 feet of gravel was exposed.

The churches of St. Augustine, St. Martin at Oak, St. Mary, St. Michael at Coslany, St. George at Colegate, St. Clement, St. Saviour, St. Paul, St. James, and St. Edmund are situated on Valley gravel or Alluvium, So also are the churches of St. Bartholomew, St. Simon and St. Jude, St. Martin at Palace, and St. Helen.

At Costessey Common there is about 7 feet of Valley gravel, which it is difficult to separate from the Alluvium.

Between Colney and Bowthorpe Hall there are indications of terraces in the Valley gravel; while further west, north of Bauburgh Hall, an old platform of Chalk borders the river. South of Bowthorpe Hall the Chalk is covered here and there with pockets of sand and gravel, and it is difficult to decide whether they belong to the Alluvial deposits or to the Crag.

A pit a quarter of a mile north-east of the letter *R* in Yare (on the map) near Eaton, showed 12 feet of stratified gravel and sand, containing pebbles of quartz and flint, angular flints, and large blocks of rolled flint and quartzite.

Some difficulty is also experienced in drawing a satisfactory line between the Valley gravel and the pebbly gravel of the Crag Series north of Cringleford Hall. Again in the valley between Rainthorpe Hall and Hall Farm, a little Valley gravel may occur, but it could not be distinguished on the map from the Crag series.

At the south-east corner of the little cemetery east of Thorpe village, 6 feet of sandy loam, containing a few stones was at one time opened up.

In the lane west of Saxlingham Thorpe Church about 12 feet of sandy loam, with angular bits of flint, was to be seen in the banks of the lane and of the stream that runs alongside it.

At the Roman Camp at Caistor, near Norwich, gravel occurs. Writing in 1822 Charles Layton, said, "The huge and massy walls of the Camp at "Caster are continually undermined by digging for gravel, so that this "venerable ruin, which, if left to itself, would last for centuries, will in a "few years be totally overthrown."*

By Postwick Hall about 7 feet of gravel has been opened up. Half a mile east of Postwick Church a gravel pit showed irregularly stratified sand and gravel resting on sands (? Crag). The beds are much disturbed in places, and contain small masses of brown drift clay.

Terraces of Valley gravel here and there fringe the marshes, and where these abut against the Pliocene gravels, as at Wroxham, Surlingham, and Langley, it is not easy to separate them from the older deposits.

"A pit situated about three furlongs S.S.W. of Loddon Church showed 4 feet of subangular flint gravel."†

"The upper part of the Alluvium in the vicinity of Reedham consists mostly of brown loam, 4 or 5 feet or more in thickness, except where trees and brushwood have grown, producing a black peaty soil for a few feet in depth. Moor and ooze, more or less intermixed, generally underlie the above."‡

Bure Valley.

The Alluvial deposits present no remarkable features in the valleys above Wroxham. Peaty deposits may here and there be traced, as at Buxton, and fringes of Valley gravel occur at Coltishall, Spixworth, and Crostwick. South of the Bridge Broad at Wroxham a terrace of brickearth occurs; and it was this deposit, perhaps, that was dug for the brickyard, now abandoned, that was situated east of the high road, and south of Wroxham Bridge.

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* Archæologia, vol. xxii., p. 412.
† From Mr. Reid's notes.
‡ From Mr. Blake's notes.

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Depth of Valleys.

At Wroxham the depth of the valley appears to be 72 feet beneath the level of the water on the left bank of the river, while it diminishes on the right side of the Bridge Broad to only 30 feet.*

This conclusion was based on the fact that in one place during the construction of the railway, the piles were driven to the depth of 72 feet before they reached the solid foundation of the Chalk, the surface of which in its true position is near the level of the water.

"Two or three trial-borings have been made in the marsh three-quarters of a mile W. of Stokesby Church, close to the mill on the north side of the River Bure, opposite Acle mill. I was informed that in each instance 21 feet of ooze was bored through, then loam was touched."†

At Norwich the soil or Alluvium was in one place 42 feet in depth. (*See* p.164.)

In the higher portions of the valleys the channels are naturally comparatively shallow. Thus at Colney, as Mr. S. W. Utting pointed out to me, the Chalk is seen on the river-bottom,

Very coarse gravel occurs in the Alluvium by Carlton Lodge, with large and nearly unworn flints that must have been directly derived from the Chalk.

Peat.

The surface-soil of the marsh lands is very generally peaty, but in few places is there any bed of peat of economic value.‡ N.W. of Boyland Hall there is a peaty bed above the Alluvial silt, so also near Buxton Church. South of the Lodge, Haynford, and at Broom Covert, Hevingham, the ground is very peaty. Some years ago peat was dug in the marshes between Brundall and Buckenham. It has also been dug east of Loddon and on Barton Marsh. In the parish of Barton Turf there is a "fuel allotment" of 30 acres.

From a memorandum preserved by Samuel Woodward it seems possible that Barton Broad was to a large extent, if not altogether, artificially formed by excavation for peat. He states, "It is most probably artificial." Mr. Gunn, sen. (the Rev. William Gunn) says that in the Norris MSS.§ it is said to have been called the "Deep Fen in the time of Edward III., and may have "become water by the continued cutting of the turf out of it, the consumption "of which must have been great prior to the introduction of coal. In fact the "borders of the Broad are an evidence of it; as they are one solid bank of turf "of considerable extent before you gain the soil or high ground. A ridge is also "left in the midst of the Broad, having at this time only about a foot of water "upon it, marking the boundary of the parishes of Barton and Irstead. There "was no appearance of this bank of turf on the sides of the Broad extending "itself into the water; but its edge appeared very clearly defined as though "kept in that state by art."¶

Hickling Broad, being likewise partly in the parishes of Hickling and Catfield, may perhaps have been enlarged in the same manner; its bottom is, however, very gravelly. (*See* p. 3.)

Mr. John Gunn says the discovery of several coins in digging turf in Catfield, near Ludham, the latest of which was of the reign of Edward VI., proves that there was water when the coins were sunk, and then peat has grown up since, "and become a solid turf ground." He adds that its estimated growth is at the rate of about a foot in twenty years; and that is formed by the annual growth and decay of several marsh plants, as *Typha latifolia, T. angustifolia, Scirpus lacustris, Cladium mariscus,* &c.‖

Mr. Gunn also says, "The broads or lakes in Norfolk are found in some "instances to grow up very rapidly by a singular process, which throws light "upon the formation of ancient turf-grounds and marshes. The water-plants

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* Gunn (Norwich Geol. Soc.), Norfolk News, May 9th, 1874.
† From Mr. Blake's notes.
‡ *See* Trimmer, Geol. Norfolk, p. 34 (Journ. R. Agric. Soc., vol. vii.).
§ Mr. Norris, of Witchingham.
¶ Trans. Norfolk and Norwich Nat. Soc., vol. ii., p. 582.
‖ Sketch of Geol. Norfolk, p. 25.

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" which fix their roots in the mud, if not cut down regularly, lose their hold, and " rise to the surface, forming floating islands. These islands become massed and " compacted together, and in time form marshy ground, leaving only a channel " for the flow of water to pass through. In some places where boats could sail " fifty years ago, people may now walk; and where there were swamps and " treacherous ground, heavy cattle are now grazing."

Fossils.

Organic remains are occasionally met with in the gravel and Alluvium; but the latter is not often opened up to any great depth beyond what is necessary for draining (*see* p. 164).

Mr. Gunn states that bones of deer and ox have been found "in the low-" level gravel skirting Barton Broad."* Stags' horns have likewise been recorded from Cringleford.

On Christmas Day, 1875, Mr. J. E. Taylor obtained a skull of *Bos longifrons* from the Alluvium near Eaton. Horns of roe-deer, *Cervus capreolus*, have been obtained by Mr. Fitch from Thorpe.

In 1842 Mr. J. O. Harper procured a tooth of *Elephas primigenius* from Markshall; and remains of *Rhinoceros* were found by Mr. A. W. Morant in a bed above the Chalk exposed at Rose Lane, Norwich. The former may, perhaps, have come from the disturbed Chalk (*see* p. 138); the latter was possibly derived from the Upper Crag.

Mr. H. Denny has recorded the discovery of the skull of a dog in a bed of gravel at the depth of 16 feet, along with the bones of deer and other animals, in the year 1851, by some workmen employed in sinking a shaft for a new chimney at the gasworks in the parish of St. Martin at Palace.

He spoke of its resemblance to that of the ancient Irish staghound, remains of which occur in the bogs in Ireland; and quoted Dr. Ball's opinion that it was a dog "of Wolfish aspect."†

In excavations at the gasworks, St. Martin's at Palace, in 1879, about 20 feet of alluvium was passed through containing many bones, as observed by Mr. T. I. Dixon.

Remains of freshwater mollusca are to be expected anywhere in the alluvium. Mr. Taylor observed many specimens near Carrow Bridge and Postwick Grove; and they have also been recorded from Cringleford.

Near Ludham Bridge Mr. Gunn obtained specimens of an estuarine shell, *Scrobicularia plana* (*piperata*).‡

In 1868 Mr. Taylor procured some peat, containing freshwater shells, from the sewage excavation then being made at Trowse Millgate, where it occurred at a depth of 8 feet below the surface. A fine fragment of an antler of the red deer, about 22 inches long, had also been taken out.§

Mr. Taylor also recorded the occurrence of piles in a peat-bed at Trowse.‖ Overlying both peat and piles was a bed of white and yellow sand and loamy clay, 4 feet in thickness and undisturbed.

Mr. Taylor described a bed of peat containing recent freshwater shells near Foundry Bridge. "It appeared that the peat was 3 or 4 feet thick, extending " from the ancient bed of the river about 100 yards in the direction of Prince " of Wales' road, where it thinned off to 3 or 4 inches against the rising side " of the valley. It rested upon angular gravel, and was covered with about 4 " feet of sand and made-earth. It was 12 feet beneath the surface near the " river, and 18 feet deep nearer to Rose Lane. There are not uncommonly in " them *pulk-holes*, so provincially called, filled with water, in which the peat " will be found, as in this instance at a lower level."¶

The following species obtained by Mr. Blake, Mr. Reid, and myself from the alluvium bordering the Chet about a third of a mile from Hardley Cross, were identified by Mr. Reid:—

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* Sketch of Geol. Norfolk, p. 24.

† Proc. Geol. and Polytech. Soc., W. Riding of Yorkshire, vol. iii., p. 538.

‡ The specimens are in the Norwich Museum.

§ Norwich Mercury, 7th March 1868.

‖ Norfolk News, 7th November 1868. Norwich Mercury, 11th November 1868; *see also* Mercury, 16th January 1869.

¶ Norfolk News, May 14th, 1870.

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Ancylus lacustris, *Müll.*
Bithynia tentaculata, *Gray.*
——— Leachii, *Shep.*
Helix.
Limax.
Limnæa auricularia, *Linn.*
——— palustris, *Linn.*
——— peregra, *Müll.*
Neritina fluviatilis, *Linn.*
Paludina contecta, *Millet.*
Planorbis complanatus, *Linn.*
——— corneus, *Linn.*
——— spirorbis, *Linn.*
——— vortex, *Linn.*
Valvata piscinalis, *Müll.*
Anodon cygneus, *Linn.*
Pisidium amnicum, *Müll.*
Scrobicularia plana (piperata), *Da Costa.*
Sphærium (Cyclas) corneum, *Drap.*

[C. R.]

Flint Implements.

Of Palæolithic implements the record is extremely scanty, in fact the only one discovered in the area is:—

"A fragment of a fine ovate implement" found by Mr. Harmer at Cringleford.*

It is quite possible that the deposit in which this occurred, like that at Hoxne in Suffolk, was cut through during the formation of the present valley. And this locality of Cringleford, together with that of Runton, are the only ones in the eastern half of Norfolk which have yielded Palæolithic implements.†

A worked flint which I picked up in a field between Boyland Hall and Hempnall, about ¾ mile west of Hempnall Church, and in the parish of Fritton, I submitted to Dr. John Evans, who observed "I am afraid that the "flint which I return herewith is Neolithic rather than Palæolithic. Of "course it may be the butt end of a Palæolithic implement, but there is a "something about it which makes me think it of later date."

One Neolithic implement is deserving of mention here, and that is a knife or lance-head found 5 or 6 feet deep in the gravel at Aldeby, now in the collection of Mr. E. T. Dowson. I also found a small ovate specimen in the talus of a low gravel cliff between the Rivers Tese and Yare, near their confluence.

* The Fenland. By S. H. Miller and S. B. J. Skertchly, p. 634.
† H. B. W., Proc. Norwich Geol. Soc., vol. i., p. 106.

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CHAPTER VIII.—PHYSICAL GEOGRAPHY.

Origin of Scenery.—The Marsh-lands.

The scenery of the district, in fact the present features of East Norfolk, date from Glacial times.

Denudation in earlier ages may have produced features that have helped to modify the subsequent action of the excavating agents, and some of these old features have been opened up again, but they must have been effaced by the chalky Boulder Clay (and to some extent even by the coarse gravels), which formed a plain extending far and wide over the Eastern Counties. Out of this plain of glacial deposits the present valleys have been excavated by rain, rivers, and tidal action.

The great valley of the Wensum between Norwich Castle and Mousehold has been hollowed out of the upper glacial beds right down to the Chalk, even some 40 or 50 feet into it, and the valley is evidently later, in its present configuration, than any glacial deposit in this county. It was no doubt commenced when the present land stood at a lower level. And it is quite possible that the agent which brought the coarse plateau gravels, marked out some of the main outlines of the present drainage systems, for in places they border the valleys and even descend into them. As the area rose the rivers excavated and deepened their channels, and when it was stationary the denudation would be directed rather to the widening than to the deepening of the courses.

Tidal action no doubt helped largely in the formation of the lower courses of the valleys, while subsequent depression must have allowed the filling in of the deeper parts of the channels, and of the formation of the Broads by flooding over wide areas previously excavated.* (*See* pp. 3, 143.)

The physical evidence and historical records indeed indicate that the marsh-lands which occupy large tracts near the mouths of the rivers, formed at one time portions of an estuary, at the mouth of which were situated the islands of Lothingland, East and West Flegg. In the course of time this mouth became contracted by the growth of sand banks, one of which stretched southwards from East Flegg; after A.D. 1000 this bank became sufficiently sound for a settlement to be made up it, and the present town of Yarmouth was founded. It was then separated from Caister by a channel called Grubb's Haven, which was closed about the reign of Edward III.

As the channels at the mouth of this estuary became closed, the influx of the tide was restricted and ultimately prevented, the rivers in the drier seasons occupied but narrow channels, and these in course of time were embanked and the marshes became dry land.

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* H. B. W., Proc. Norwich Geol. Soc., vol. i., p. 63.

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The marshes consequently remain in many places beneath the level of the sea and of the rivers, and from the sea they have at times been flooded by the destruction of the sand banks, while over a considerable area they are usually under water from the "freshes" of the river during the winter months.

Now the denudation is more extensive in the higher courses of the rivers than the lower, where indeed they are partly engaged in silting up their valleys by a process of warping in seasons of flood.

As Mr. Gunn has remarked† the geological evidence does not point to the sea having come up as far as Norwich during Roman or Saxon times, though it may have done so previously, for the alluvial deposits of the Yare seem to be entirely freshwater. But the sea no doubt occupied the valleys at Horning and above Reedham in historic times.*

"Camden, in his Britannia (Gibson's edition, p. 390), states that 'cockles' had been dug up near St. Benedict de Hulmo, from which it was inferred that the sea formerly extended to that neighbourhood."‡ Their proximity to the abbey, however, throws a doubt upon their testimony.

The tradition that the sea once had possession of the valley as high up as Norwich was supported, if it did not originate, in the finding of the sea shells of the Crag at Bramerton and other places on the borders of the river, which before stratigraphical geology was understood were thought to be Valley deposits.§ (*See* p. 81.)

Some support has also been derived from certain historical statements. Thus—

The Saxon Chronicle relates the fact that (A.D. 1004)‖ "this year came "Sweyen with his fleet to Norwich." But these vessels did not draw much water.

Norwich also is spoken of as having been a fishing town in the reign of Canute; and Blomefield considered it probable that it had its origin "by fisher-"men and merchants fixing here for traffick sake."¶ The site of St. Lawrence's Church was originally a quay or fishing staithe, whereas now the river is about 10 feet below the adjacent streets, and about 25 feet before the church. Subsequent embankments reduced it to its present circumscribed limits. These embankments may be seen on the Hospital and precinct meadows.**

It has been thought that the word Yare, derived from the Celtic *Garu*, signifying rough, referred to its former estuarine and agitated condition.††

From these statements, and others that follow, it may be concluded that at any rate the rivers were less confined than they now are, spreading further over the alluvial tracts in their ordinary course, and being liable to more frequent and more copious floods by reason of the increased influence of the tide.

The River Tese, it is stated, was once navigable by Caister St. Edmund, or Caistor-next-Norwich, to Tasburgh. And it is considered that about the time

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* *See* R. C. Taylor, Geology of E. Norfolk, p. 41; S. Woodward, Hist. and Antiq. of Norwich Castle, *Appendix*, p. 48; Gunn, Norfolk News, Feb. 8, 1879; Lyell, Principles of Geology, ed. xi., vol. i. p. 521.

† Norwich Mercury, Dec. 17, 1873.

‡ Robberds, Geol. and Hist. Observations on the Eastern Valleys of Norfolk, pp. 9–11, &c.

§ *See* Arderon, Phil. Trans., Abrid. by Martyn, vol. x., p. 590.

‖ In the "Chronica Johannis de Oxenedes" the date is given as 978; Robberds, Eastern Valleys of Norfolk, p. 53.

¶ History of Norwich, pt. i., p. 81 (1806).

** S. Woodward, MS. 1824. (Letter to T. Aymot, July 23, 1824.)

†† Munford, Local Names in Norfolk, p. 231.

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of the Emperor Claudius (A.D. 46) the Romans built the castles at these localities to fortify themselves against the Iceni, and guard the streams which were then navigable.*

The exact date at which the rivers were embanked is not on record; in the 12th century there is evidence to show that the marshes occupied much the position they do now. R. C. Taylor tells us that "the bridge called Weybrigg, "at Acle, and the great causeway connecting with it, were certainly in existence "in the 11th century; and we find that payments were made towards their "*repair* in 1101, and succeeding years. This causeway is so little above the "present level of the river and marshes, that even in our own times it has been "repeatedly overflowed."

He also states "that the river which divides the hundreds of Flegg and "Happing was embanked previously to 1274 near the Abbey of Holm; for "in that year occurred a dispute about the right of fishing from the river's "banks." †

Other evidence brought forward in reference to the presence of the sea at Norwich in historic times has been proved to have no satisfactory foundation. Thus Robberds has stated that—

"In the year 1805 I was present at the sinking of a well in the garden lately occupied by Dr. Alderson in the parish of St. Clement (near Fye Bridge), in Norwich, where, at about 10 feet below the surface, a bed of shells was found, consisting almost entirely of the *Cardium edule*, in a very perfect state of preservation." He also mentioned that—"The meadow bank of the river, between the Foundry and Carrow bridges, presents, when the water is low, a bed of fossil shells, some fluvial and some marine, lying in a sandy stratum immediately under the superficial deposit of black alluvial mud."‡

In commenting upon these statements Samuel Woodward has referred also to "the stratum of welks and oyster shells noticed by Arderon (Journal, July "16, 1757), and which was discovered in digging a pit, about 6 feet deep, in the "garden of Mr. Woodrow, master weaver, in St. George's." These he considered to have probably had the same origin as those found in the parish of St. Clement, the localities being the site of the Black Friars grounds: so also in respect to the remains found near Carrow Abbey (*see* p. 69); all in fact had some connection with the ancient monastic esbtalishments.

From what has been said before it is highly probable that the areas now occupied by the Broads (as maintained by Mr. R. B. Grantham§) were at one time portions of estuaries, and that these lower parts of the valley have been excavated by the combined action of river and sea. When the sea was cut off the area, fresh waters entirely occupied the valleys, from which they are now to some extent retreating by the infilling and contraction of the Broads.‖ (*See* pp. 4, 143, 146.)

Even in historic times the sea has broken through the barriers between Waxham and Winterton, flooding the marshes that are below the level of high tide and killing fish in some of the Broads, as at Hickling whose bottom is still below the sea-level, and where pike and bream are even now occasionally killed at unusually high tides.¶ (*See* pp. 150, 151.)

Messrs. Brady and Robertson, in an interesting account of the Ostracoda and Foraminifera, notice the occurrence in the more

* Blomefield, Hist. Norwich, 8vo. 1806, pp. 1, 2.
† R. C. Taylor, Geology of E. Norfolk, pp. 38, 39.
‡ Robberds, *op. cit.*, p. 9.
§ Quart. Journ. Geol. Soc., vol. xxv., p. 258.
‖ The Rev. O. Fisher and Mr. J. E. Taylor have advocated the glacial excavation of the Broads. Geol. Mag., vol. iii., p. 487; Trans. Norf. and Norwich Nat. Soc., vol. i.
¶ *See* Lubbock's Fauna of Norfolk, Edit. 2, by T. Southwell, pp. 189, 193.

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remote Broads of Norfolk of purely marine or decidedly estuarine species; but these they think must have been introduced when the district was overspread by the sea, and they saw no difficulty in understanding that this fauna "should hold its ground for a "lengthened period, while its habitat was year by year becoming "less subject to marine influences, and that the more hardy or "more plastic species should remain even after freshwater entirely "usurped the place of salt."*

It has been recorded in the Domesday Book (A.D. 1086) that salt works were established at South Walsham, Halvergate, and Cantley, besides many other places not in the area now under consideration.†

Halvergate is said to have been a seaport before the land was formed on which Yarmouth is built.

These memoranda are not without importance in the history of the Broads. Some remarks on their dimensions, as well as upon the rivers, will be found in Chapter I.

FLOODS, ETC.

It seems desirable to supplement this portion of the work, which deals with the changes that have taken place in later geological times, with an account of the inundations to which the district has recently been subjected.

As pointed out by Sir Willoughby Jones, almost the whole of the upper and non-navigable portion of the Norfolk rivers has been utilized for water-mills, the rivers themselves being converted into raised water-ways or canals of comparatively still water, between each fall of three or four feet at the mills.

"Alongside of the river there often runs a little subsidiary river, called a soke drain, intended to catch the flood water, and having its outlet in the next mill-pool, a narrow ditch, perfectly ineffectual for any drainage purposes, and the land on both sides is occasionally inundated, and always swampy and greatly injured by water."‡

The chief portion of the lower marshes, even as high up as Buckenham and St. Bennett's Abbey, is from 18 inches to 2 feet below the surface of the rivers.§ In these tracts the flood water is pumped out by drainage mills.

The accompanying record of inundations that have (or may have) affected the district has been compiled from the following sources:—

Chronica Johannis de Oxenedes. (Edited by Sir Henry Ellis. Lond. 1859.)

Blomefield, Rev. Francis. The History of the City and County of Norwich. 8vo. Lond. 2 parts. 1806.

Walford C. The Famines of the World; Past and Present. Of the Floods and Inundations of the World. Journ. Statistical Soc., vol. xli., 1878, pp. 451–468.

Norfolk News, Nov. 30, 1878.

East Anglian Handbook for 1879.

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* Ann. Mag. Nat. Hist., vol. vi. (1870), p. 4.

† Robberds, Observations on the Eastern Valleys of Norfolk, 1826, p. 26 The village of Salhouse may possibly be included; though it has been suggested by Munford (Local Names in Norfolk) that the word may simply mean Salt's house, Salt being a personal name, meaning a seaman or old salt.

‡ The Arterial Drainage of Norfolk, by Sir W. Jones, Bart.

§ R. C. Taylor, Geol. E. Norfolk, p. 36.

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A.D.

575. Part of Norfolk inundated from the sea. (Walford.)

1251. Destruction by sea. (John of Oxnead.)

1271. A very great flood which did much damage to the city and adjacent country. (Blomefield.)

1280. Great tempests and inundations, which did much damage to this city and country. (Blomefield.)

1286. January 1. Marsh lands flooded by sea. (John of Oxnead.)

1287. December, and 1288, January. Sea broke in on Norfolk coast. Marshes flooded and freshwater fishes killed. The wind and violence of the sea carried away houses in Yarmouth, Dunwich, Ipswich, and Marshland. (John of Oxnead.)

1290. January. "1290, on *Wednesday* after the Feast of the *Epiphany* was "a great flood, which did much damage to the city. The water came "down (the river) in such abundance that it went over St. *Martin's* "(Whitefriar's) Bridge, and ran even to the gates of St. *Giles'* (now "St. Helen's) hospital, and washed down many houses by its vio-"lence." On the 17th of the month the water again overflowed into Bishopsgate nearly to "St. Giles' Hospital." (Blomefield.)

1361. The "rains were so great that at hay-seal and harvest there were "such inundations as did abundance of damage." (Blomefield.)

1519. November 6. "On St. *Leonard's* day happened a flood, which over-"flowed great part of the city, and broke down *Cringleford* bridge; "it was called St. *Leonard's* flood." This was evidently occasioned by a heavy rainfall. (Blomefield.)

1564–5. "After Michaelmas this year (1564) fell so much rain that much winter corn could not be sown, and eight days before *Christmas*, began a very great frost, which lasted nine weeks, so sharp that most of the sheep perished, and the greens, as hollies, furze, laurels, &c., were killed; and by the thaw, which was a very sudden one, great floods ensued, and much damage was done to the mills, bridges, and banks in most places." (Blomefield.)

1570–71. "Ten days before *Christmas* there began a snow, which increased to such a depth in the *Christmas* holidays that the like had not been known in the memory of man; it continued, by reason of the sharp frost that attended it, till *Candlemas* day (February 2nd) when it began to thaw, and then the water rose exceedingly, so that on *Saturday* morning the 5th of *February* all the part of the city on the north side of the river was totally overflown, and it continued rising till the *Wednesday* following . . . it not only threw down many stone walls and buildings, "but removed the stooles in all the churches on "the other side of the water, except St. *Augustens*; and the water at "this flud was a handfull higher than St. *Leonard's* flodd."* This was called *Candlemas* flood. It did incredible damage at Yarmouth, Dunwich, Wisbitch, Lynn, and Marshland, as *Holinshed* shows us." (Blomefield.)

1579. "According to *Norwich* Roll in *September* was a great flood, and a greater about a month after, which did much damage." (Blomefield.)

1608. "At this time there were such violent *inundations* occasioned by the high winds that incredible damage both to houses, men, and beasts was done in many parts of *England*, and in several places of this county, to such a degree that an Act passed for the speedy recovery of many thousand acres of marsh and other grounds lately overflown, &c., in the county of *Norfolk*, and for the prevention of the like hereafter; which sets forth that a part of the sea shore lying between the towns of Great *Yarmouth* and *Happisborrow* (or *Haseboro*) lying low, and being sand only, was lately broken down and washed away by the violence of the *tides*, so that the *sea* broke in every *tide*, and with every sea-wind came up the *Norwich* river into the very body and heart of the county of *Norfolk*, drowning much hard grounds

* Lib. Civit. Hol. 1222, vol. ii.

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A.D.

and many thousand acres of marsh, upon which great part of the wealth of the county depends, being most rich grounds: and without which the *uplands*, which are mostly dry and barren, cannot be husbanded; and by means of the salt water the *fisheries* between *Yarmouth* and *Norwich*, as well in rivers as broads, were much damaged, so that the great plenty which used to maintain many poor men was gone, and the markets badly served with fresh fish;" . . . "Among the towns that were damaged are mentioned "Possewick, Thorp by Norwich, Trowse, and Carrow." (Blomefield.)

1614–15. In 1615 so great were the inundations in *Norfolk* that the sea came 12 miles into land; and on St. *Andrew's* day (November 30) there was such a flood in the city that it was as high as *Candlemas flood* within two inches; it did much hurt in the churches, cellars, houses, tanners' yards, &c. . . . There began a snow and frost the 20th of *January*, which continued eight weeks, and when it brake up much damage was done here by a flood on the 15th of *March*. (Blomefield.)

A mark on the stone in the New Mill Yard records the highest flood known, as occurring in 1614.

1646. November 15. A very great flood, so that boats were rowed in *St. Edmund's*, *Magdalen*, and many other streets in the city. (Blomefield.) Mark on stone in New Mill Yard.

1673. "An extraordinary deep snow fell *February* 24 and till *Easter* following, "being seven weeks; and when it thawed such a flood followed that "*Hellesden*, *Trowse*, and many other bridges received great damage." (Blomefield.)

1696. "It began to rain *October* 4th at night, and continued without intermission (except a few hours on the 6th day) till the 10th at noon, which caused such a rage of waters as overflowed the lower part of the city, and did much damage; it broke down *Trowse*, *Harford*, and *Bungey* Bridges." (Blomefield.)

This is spoken of as the St. Faith's Flood, from the church of St. Vedast, commonly called St. Faith's, which stood near the top of Rose Lane, but was long ago demolished.

1706. The *Norfolk and Norwich Remembrancer* speaks of a great flood in November 1706; Blomefield says there were "two great floods" in that month. A great part of the city was flooded.

1734. December 31. "The greatest flood known since 1696, all Heigham "was under water, and several streets in the lower part of the city, so "that boats rowed in them." (Blomefield.) Mark on stone in New Mill Yard.

1737. October 4. "A very great flood" in the lower part of the city. (Blomefield.)

1739–40. The "Hard winter." "This winter was extremely cold and sharp; "a deep snow fell about *Christmas* day and laid till *March*, and when "it brake up was a prodigious flood." (Blomefield.)

1762. October 27. A sudden flood which affected nearly all the parishes on the north side of the river. "The water rose 12 feet perpendicular," it was said, "in 24 hours. It was 15 inches higher than St. Faith's flood in "1696; eight inches lower than that in 1646; and 13 inches lower "than St. Andrew's flood in 1614." There is nothing in any of the published records to show whether heavy rains or high tides had a preponderating influence in causing this disaster. It laid under water between 2,000 and 3,000 houses, and the churches of St. Miles (St. Michael at Coslany), St. Mary, St. Martin at Oak, St. Paul, St. James, St. Clement, St. Edmund, St. Helen. Mark on stone in New Mill Yard.

1770. November 19. Great flood that rose within four inches of the height of that of 1762. Mark on stone in New Mill Yard.

1770. December 19. Greater storm of wind and rain than had been known since 1741. Part of the city wall, between Brazen Doors and Ber Street, fell.

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A.D.

1779. New year ushered in with a terrible storm of wind, which rolled up the lead of St. Andrew's Church, and blew it to a considerable distance.

1794. November 6. The Norwich Mercury, of November 8th, says, "In consequence of the late heavy rains the parishes of Heigham, St. Martin-at-Oak, St. Mary, St. Michael Coslany, St. Swithin, St. George of Colegate, St. Edmund, St. Clement, &c., have been flooded, and boats were rowed about several streets."

1795. February. Rapid thaw produced such a general inundation in the city and suburbs that the poor inhabitants of Heigham near the river, were reduced to great distress.

1799. February. A deep snow obstructed for a time all travelling and internal communication, and the mail coaches were four days and nights in performing the journey from Norwich to London. In many places the snow was 20 feet deep.

1809. January 28. District of Heigham flooded so greatly after a rapid thaw that boats could be rowed in the streets.

1878. November of this year witnessed such a flood in Norwich as had not been known since 1646. It was chiefly felt above the New Mills, where the Wensum flooded a large district in Heigham, but the lower portions of the Yare valley were entirely under water, the ferry-houses of Surlingham, Coldham Hall, and Cantley being flooded to the depth of several feet, while at Trowse and in the higher portions of the valleys of the Yare and Tese the alluvium was covered for a considerable distance.

Up to the time of the flood (November 16–17) from 4 to 8 inches of rain had been registered in the valley of the Wensum*; rain fell on every day from November 1st until the 17th. And on the 16th an unusually high tide at Yarmouth served to keep up the flood-waters in the valley and prevent the rivers from carrying them off. Moreover, on the 12th, there had been a heavy fall of snow, and this had rapidly thawed just before the flood.

The New Mills† acted as a dam. Whatever outlets there were, became choked up with drift wood, hay, broken boats, fences, and other materials, and consequently the waters were dammed up and eventually rushed over the banks above on either side, and submerged a large district in Heigham. Mr. Marshall, the city engineer, stated that "The New Mills dam was the main cause of "the floods." And, "When the water was at its highest, both "above and below the New Mills, there was a difference of 3 feet "6 inches between their respective levels."

"The backed-up waters (in the river valley below Norwich) "reduced the effectiveness of the sluices at the New Mills by "lowering the head."

The first alarm connected with the rising waters was given on Saturday afternoon, but the city was not fully alive to the danger until late in the evening. The waters gradually rose in Heigham Street, Heigham Causeway, Lower Westwick Street, and spread up Barn Road, Canterbury Place, Sayer's Buildings, Derby Street, Albert Street, Russell Street, Napier Street, Lothian Street, &c. From three to six thousand houses were several feet under water before night. In St. Martin's and all the yards near the river, a similar state of things prevailed. On the 17th (Sunday) the waters had risen 10 feet above their ordinary level.

The Wensum spread from 25 feet to nearly one mile in width. Heigham Street and Causeway, and Lower Westwick Street became a deep river flowing through the courts and passages in St. Margaret's into the river. Cottages in the Old Palace Road were submerged to a depth of from 2 to 4 feet. The Anchor Brewery was inundated.

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* Mr. Marshall states (Norf. News, Jan. 11, 1879) that the actual rainfall recorded in Norwich for the first 16 days in November 1878 was over 6 inches.

† Built 1429, rebuilt 1710.

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St. Mary's plain was covered with water, and in the churchyard the tomb-stones were scarcely visible. At St. Martin's at Oak the water partly submerged the tombstones, and St. Martin's Street had the appearance of a river. St. Miles' parish was inundated, and the water was within one foot of the crown of the bridge. Fye Bridge Quay was under water.

Many houses suffered from the rising of water through the soil and sewers. At the four cross-ways by St. George's Church there was a large pool of water which had arisen through the gratings of the overcharged sewers. Other pools appeared in Colegate Street, by Magdalen Street, and by the Old Man's Hospital.

On Sunday evening at 10 p.m. the waters abated 6 inches, and by 11.40 to the extent of 3 feet.*

At Beccles the Waveney overflowed and flooded the marshes to the depth of several feet, but the Corporation marshes, protected by a raised bank, escaped. Communication between Norfolk and Suffolk was intercepted by the water, which covered Gillingham Dam to the depth of 3 or 4 feet, and in several places washed over the raised footpath. The low-lying lands of the Waveney Valley were covered for miles.†

A study of this record shows that the river-valleys have been ever subject to floods, sometimes from heavy and continuous rainfall, sometimes from heavy falls of snow and rapid thaw, from the blocking of the river by ice, and sometimes from inundations of the sea.‡ These causes may act independently or together.

The irruption of the sea is only to be prevented by the permanence of the sea-walls.

The increased systems of drainage help to carry the water off the land more rapidly now than in former times, hence with very heavy rainfall the liability to floods is increased rather than diminished, for the rivers are not capable of carrying off the water with sufficient rapidity.

The flat alluvial meadows that border our rivers are after all the property of each river, over which it has been accustomed to flow, for the substance of the alluvium is largely the warp laid down in times of flood; indeed its level is sometimes considerably below (as much as 7 feet) the level of high tide at Yarmouth.

The remedies proposed by Sir John Hawkshaw are to embank the rivers Waveney, Yare and Bure, within the tidal region, and the low-lying lands above that region where the fall is insufficient; to deepen and enlarge when necessary the channels in the upper and lower reaches; and to provide additional pumping power to raise the water from the low lands into the higher level of the rivers.

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* J. Quinton, jun., Trans. Norf. and Norwich Nat. Soc., vol. ii., p. 608; East Anglian Handbook for 1879; Hickling's Almanack for 1879; Norfolk News, Nov. 23, 30, 1878 (Reports by M. Knights); Norfolk News, Jan. 11, 1879.

† East Anglian Handbook for 1879.

‡ The last occasion when the sea broke in was at Waxham in November 1800.

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CHAPTER IX.—ECONOMIC GEOLOGY, &c.

A.—Water Supply and Wells.

The subject of floods noticed in the last chapter leads us naturally to consider that of the water-supply.

It appears likely with increased systems of drainage that the rainfall will not only be more rapidly carried off the land, but less of it will sink into the porous strata. Be this as it may, the tract under consideration possesses good natural supplies and reservoirs of water.

The water-bearing strata are the Chalk, the Norwich Crag Series, the Glacial sands and gravels. Of these the Chalk alone can be depended upon for any considerable supply of water. From it, as Mr. Sutton has remarked, we obtain "the most whole-"some water-supply, and when supplies can be drawn from it "without surface contamination the water leaves scarcely anything "to be desired except on the score of its hardness."*

The Chalk is exposed at the surface over very limited tracts in the area, and the tracts are not large over which it is overlaid by porous strata only. But the Chalk is not dependent for its water-supply to the direct rainfall of the district. In West Norfolk it appears at the surface over more extensive areas, and its easterly dip helps the distribution of the underground waters into the Chalk of the eastern part of the county.

It has been stated that a cubic foot of Chalk will hold about two gallons of water, but as its texture is too close to allow water to filter freely through it, the rainfall passes away chiefly through the rubbly and fissured surface, the joints, and along planes of bedding. Hence it is that the water met with in the Chalk occurs at very uncertain levels, and occasionally, as at Diss, no supply whatever may be passed through in penetrating it.†

Where the Chalk is not exposed at the surface, nor covered with Alluvial deposits, it is almost everywhere directly overlaid by the Crag Series, the pebbly sands and gravels streaked with laminated clay. These furnish a supply of water to wells from 10 to about 100 feet in depth, and this is supported by the Chalk itself, which being penetrated a few feet may serve as a reservoir. Over the greater part of the area the Crag Series is covered with Glacial deposits (brickearth, sand, gravel, and boulder-clay), and where these are of an argillaceous character, the strata are free from all surface contamination, and, as Mr. Sutton observes, "are plentiful in water supply of good quality." He adds "This class "of well is the only one beside the true Chalk wells which ought "to be tolerated as a water-supply for domestic purposes in this "district."‡

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* Proc. Norwich Geol. Soc., vol. i., p. 86.

† *See* Prestwich, Water-bearing Strata of the Country around London, p. 57.

‡ *Op. cit.*, p. 87; *see also* p. 105.

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The Crag Series, it must be remembered, contains beds of laminated clay (the so-called "Chillesford Clay") at inconstant horizons and of uncertain and very limited extension, which may act as local supports for the water-supply, or as checks to the percolation of water charged with organic impurities, where no Glacial clays occur above.

Over almost the entire area embraced by Quarter-sheet 66 S.E. where the chalky Boulder Clay appears at the surface, the Crag series might be expected beneath at depths of from 10 to 100 feet, and indeed it yields much of the water used in that district.

The so-called "Middle" Glacial sands and gravels resting on the Lower Glacial Brickearth or Contorted Drift, yield supplies of water to wells varying in depth from about 10 to 30 feet. Where covered by the chalky Boulder Clay, as in the neighbourhood of Halvergate, Tunstall, or Clippesby, the water would be protected from surface contamination, to which over the greater part of the area of 66 N.E. that obtained from these Glacial sands is liable.

The chalky Boulder Clay is not unfrequently excavated to serve as a tank for the water-supply of cottages over the area occupied by this formation: a plan much to be deprecated, as the water entirely dependent upon the rainfall, soon becomes unfit for drinking-purposes.

Water obtained from the sand and gravel on the chalky Boulder Clay is liable to the same objections as that derived from the sands and gravels that overlie the Lower Glacial brickearth, when there is no superincumbent layer of clay.

The shallow wells sunk in valley-gravels, as in some of the lower parts of Norwich or at Bungay, are almost invariably subject to contamination, and the water should not be used for drinking purposes.

It has been stated by Messrs. Taylor and Morant, that "During the progress "of the sewerage works (in Norwich) several pumping-engines have been "working night and day, lifting about 17,000,000 gallons of water in each "24 hours. The wells for two miles round Norwich have mostly been "drained, although the river, which flows through the middle of the drained "area, has been unaffected. The wells sunk in the solid undisturbed Chalk "were those first affected; the wells situated in the re-deposited Chalk, or "'chalk-marl,' being so in a less degree. Wells on the higher grounds, "sunk through the sand and gravel, have been untouched, especially if they "had a bottom of brickearth. In practical well-sinking it has been found "necessary to bore through the re-deposited Chalk until the underlying hard "chalk, into which it gradually passes, was reached, where water is found in "abundance. The thickness of this marl varies from 10 to 30 or 40 feet."* (*See* p. 134).

Norwich is, however, well supplied from the river Wensum, and the water, Mr. Sutton has stated, "is so efficiently filtered, aërated, and stored, under "the able management of our Norwich Waterworks Company, that its con-"dition, as delivered under constant pressure to the City, leaves nothing to be "desired."†

* Geol. Mag., vol. vii., p. 121.
† *Op. cit.*, p. 91.

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The following details respecting well-sinkings will be useful in showing the thicknesses of strata penetrated in various parts of the area.

Analysis of the waters at Carrow, Taverham, and Beccles, as well as of that supplied from the Wensum (in 1872), are given in the *Sixth Report of the Commissioners appointed in* 1868 *to inquire into the best means of preventing the Pollution of Rivers*, 1874.

BECCLES.—Waterworks, 1870–71. (*See Diagram.*)

Communicated (to Mr. Reid) by Mr. W. M. Crowfoot, M.B., M.R.C.S., from details furnished by Mr. T. M. Quill, combined with a personal inspection of the materials brought up. See *Proc. Norwich Geol. Soc., vol. i., p. 76.*

The wells are situated about three-quarters of a mile south of the centre of the town, where the ground rises to a height of about 100 feet above the sea-level at Lowestoft. Two borings were made about 100 yards apart, one being sunk in 1870, the second in 1871.

Mr. Crowfoot states the "Water first occurred in the Chillesford Sands, "held up by the clayey beds beneath. It was abundant and of good quality, "and at a depth of 10 feet in these sands, a well 4 feet in diameter supplied "21,000 gallons per day, without appreciably lowering the top water-level. "This is the water-bearing stratum generally round Beccles, most of the wells "being sunk into it." (*See* p. 88.)

"The dark silty or muddy bed beneath had a foul marshy smell, which continued for a depth of about 35 feet. * * * The shells obtained in this bed, which were stained of a dull leaden colour, were considered to belong to the Fluvio-marine Crag of Mr. S. V. Wood. (*See* general list, p. 42.)

"Although it seemed that 68 feet was an unusual thickness for Norwich Crag, Mr. Dalton had ascertained that at Saxmundham a well-boring gave 105 feet of Pliocene strata, including the Chillesford and Fluvio-marine divisions. At Beccles these same beds have a thickness of 95 feet; a thickness which has also been proved to be as much at Framlingham. * *

"In one of the wells at Beccles a boring was carried for 60 feet, and in the other for 73 feet into the Chalk, which was hard, and contained beds of flints at intervals. It yielded in both wells an abundant supply of water."†

Including the Bure Valley Beds, and other divisions of the Crag series, we have here the record of a thickness of 128 feet of the Pliocene strata.

BECCLES.—Messrs. Worthington & Co.

Sunk and communicated by Messrs. LEGRAND and SUTCLIFF to Mr. W. WHITAKER.

	FEET.
Gravel, sand, &c. - - - - - -	58
Chalk, the upper part like pipe-clay - - - -	26
	84

The following notes of wells at Beccles were made by Mr. REID:—

A well at the Cemetery on the London Road was dug in sand and a little gravel to a depth of 48 feet, shells occurred at the bottom.

A well at the stonemason's in the Station Road was dug in sand to a depth of 18 feet.

Opposite the free school a well was dug 46 feet deep: shells were met with at the bottom.

In Darby's Brickyard, 1 mile S. of Beccles, the well was said to be 60 feet deep (10 feet water), all "in sand and stones, rougher lower down."

At Fair Close a well was dug through 15 feet of Boulder Clay to shelly Crag.

† Proc. Norwich Geol. Soc., vol. i., p. 77.

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[*To face p*

f No. 1; 12 feet diameter for 84 feet, thence 10 feet.
N lower, then a 9-inch diameter bore pipe.

ground 107 *feet over Sea Level.*

	ft.	in.	
	1	0 —	Vegetable soil.
Soil, 1 fo	2	6 —	Yellow clay.
			Blue boulder clay.
Blue clay	7	9	
[Chalky			
	7	0 —	From 107 to 110 feet is mingled with dark slimy clay.
	0	0 —	
	5	0 —	At 116 feet down numerous pieces of broken shells occur, echini and others.
Muddy sil vious to			
[Fluvio			
			At 134 feet down the sand became clean, free from mud and smell, and the shells ceased.
			Under this to 137 feet numbers of rolled rounded nodules of clay occurred in sand.
	57	0 —	Depth at which Chalk was reached.

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At Rose Villa, Fair Close, the well was dug in Clay and Chalk, 30 feet, to gravel.

The well at the house about 10 chains North of the Pot Yard, Beccles, showed 12 feet of gravel (valley gravel ?).

C. REID.

BEDINGHAM.

Sunk and communicated by D. PALMER to Mr. C. REID.

		FEET.
[Chalky Boulder]	Clay	30
[Glacial Drift and Crag ?]	Sand and brickearth	30
		60

BIXLEY.

Communicated by G. C. BURROWS to S. WOODWARD, MS. 1825.

		FEET.
[Chalky Boulder Clay.]	Brickearth	2
	Blue clay with chalk concretions	30
[Glacial Drift and Crag.]	Gravel and white sand	20
[Chalk.]	White Marl	30
	Chalk	10
	Hard chalk	15
		107

BIXLEY.—The Hall.

Communicated by Mr. D. PALMER, well-sinker, to Mr. C. REID.

		FEET.
[Chalky Boulder Clay.]	Very chalky clay	20
[Glacial Drift.] [Crag.]	Gravel and sand - Well-worn shingle.	100

Mr. Lawrence, well sinker, informed me that there is a well at Bixley Hall through 100 ft. of clay to black gravel with bad water.

C.R.

BROOME.—Coopers Farm.

From information obtained by Mr. REID.

		FEET.
[Chalky Boulder Clay.]	Clay	12
	Gravel and sand (none fit for mortar)	46
		58

BUNGAY.—Uplands Mill.

From information obtained by Mr. REID.

	FT.	IN.
Whitish sand and a little gravel	10	0
Brickearth	0	6
Brown and orange gravel	30	0
	40	6

BUNGAY.—Castle.

Communicated by Mr. D. PALMER to Mr. REID.

Old Well, 60 or 70 feet deep. The pump rods were covered with a peculiar blue crust.

BUNGAY.—Market Pump made 1812.

Communicated by Mr. PALMER to Mr. REID.

Well, 35 feet, all sand and gravel.

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BUNGAY.—Hospital.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Sand and gravel	20

BUNGAY.—Tylor, above the Thatched House Inn.

Communicated by Mr. LAWRENCE to Mr. REID.

		FEET.
[Chalky Boulder Clay.]	Clay	40
	Sand	60
		100

BUNGAY.—Stow Park Farm.

Communicated by Mr. PALMER to Mr. REID.

	FEET.
Boulder clay	25
Sand and gravel	55
	80

SOUTH BURLINGHAM.—Old Hall.

		FEET.
[Glacial Drift.]	Loam Sand.	12

70 or 80 feet to water.

H. B. W.

DENTON.—Mr. Doole's.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Clay, about	71
Sand, to water, about	18
	89

DITCHINGHAM.—Mrs. Margetson's, Ditchingham House.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Clay and brickearth, about	36
Sand, about	40

A bed of shells 7 feet thick, without sand, at the base. Water rather salt.

DITCHINGHAM.—Mrs. Menzies, ¼ mile N. of Cold Bath House.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Clay	50
Sand	25

At the base were found the following shells (in Mr. Hartcup's possession):—*Purpura lapillus, Litorina litorea, Cardium edule, Mya arenaria, Tellina obliqua, T. prætenuis, Cyprina Islandica.*

DITCHINGHAM.—The Lodge. (D. PALMER.)

8 or 9 feet of hard shelly crag was met with in the well.

EARSHAM.—Mr. Pipes, half a mile W.N.W. of the Hall.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Chalky Boulder Clay	90
Sand, to water	4 or 5

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EARSHAM.—The Hall.

Well sunk through clay, sand, and gravel, 74 ft. to shells?

(C. REID.)

EARSHAM.—The Park.

Communicated by Mr. PALMER to Mr. REID.

	FEET.
Boulder clay - - - - - - -	25
Sand and gravel - - - - - -	45

EARSHAM.—Hall farm.

Communicated to Mr. REID.

	FEET.
Soil - - - - - - -	1
Yellow loam - - - - - -	1½
Blue clay and chalk - - - - -	60
Clay with Lias - - - - - -	6 or 7
Blackish loamy sand - - - - -	5 or 6
Red gravel - - - - - -	7 or 8
Black loam - - - - - -	10
Total depth	92 feet.

EAST CARLTON.—Hall.

Communicated by Mr. SWAN to H. B. W.

		FEET.
[Upper Glacial Drift.] [Crag.]	Gravel, Clay, Gravel	30
Chalk.		

FLIXTON.—Mr. Harris.

Well about 75 feet (LAWRENCE).

FLORDON.—Well by Inn near Railway Station.

Information given by Mr. W. H. LOCKWOOD to H. B. W.

	Boulder Clay.
[Crag.]	Sand and gravel.
	Chalk.

Water obtained at depth of 60 or 70 feet.

FRAMINGHAM.

"Chalk found at a depth of about 30 feet in digging a well."—Dr. RIGBY, Framingham, its Agriculture, &c., p. 47.

FRAMINGHAM PIGOT.—¼ mile N.N.E. of Gull Inn.

	FEET.
Soil and chalky boulder clay, Sand and gravel - - - - - -	62

H. B. W.

GELDESTON.—Well at the Old Brewery.

Communicated by Mr. D. PALMER to Mr. C. REID.

Well in 15 feet of gravel and sand, the bottom not over 4 feet above the river; water at 11 feet. Then bored 65 feet in bluish sand, no gravel or clay, 3 or 4 feet in white clay (chalk?). The total depth is 80 feet from the surface, not 84 feet as shown by the details. At first the water supply was 36 gallons per minute. The well is now disused, and I am told the supply failed.

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GELDESTON.—Well at Messrs. Dowson's Malthouse, No. 3, 1875.

Communicated by Mr. E. T. DOWSON.

We took a small quantity of sand with small rounded stones from bottom of well, at a depth of about 8 feet.
Top of well about 4 feet above river.

GELDESTON.—Well at Mr. James Boggis' house, 1865.

Communicated by Mr. BOGGIS (who gave it from memory) to Mr. E. T. DOWSON.

	FEET.
Clay, varying from brown to blue	20
Sand (white) with few stones	7
Gravel with smallish stones	6
Blue clay	?

GELDESTON.—Well at Mr. Crisp's Malthouse (No. 2), November 1870.

Communicated by Mr. E. T. DOWSON.

	FEET.
Sand with small subangular gravel, principally flint and one or two quartz pebbles	7
A stiff bluish white clay containing a great many chalk nodules and a few flints	2
Passing into a clay resembling it but with some sand	3
A dark red ferruginous gravel (subangular) containing principally smallish flint stones and a few quartz and quartzite rounded pebbles	4

I saw some of the clay that was taken out, and still possess some.
Top of well about 10 feet above river.

E. T. D.

GELDESTON.—Hall Farm. (C. REID.)

	FEET.
Clay	25
Sand and gravel	65
	90

GILLINGHAM.—Keeper's House. (C. REID.)

	FEET.
Clay (land spring)	72 or 73

GILLINGHAM.—At Mr. Marsh's.

Communicated by Mr. PALMER to Mr. REID.

Well 95 feet, 30 or 40 feet of clay, the rest sand.

GILLINGHAM.—Well 5 chains W. of *T. G.* (on map). From information supplied (to Mr. REID) by Mr. E. T. DOWSON, who saw the material and obtained the thicknesses from Mr. YOUELL.

	FEET.
"Sand, brownish and almost pure"	6
"A white very chalky boulder clay (upper glacial without doubt according to appearance. It contains much flint and some foreign boulders, and an oyster which I have)"	13
"A blue clay containing chalk nodules was bored through. To all appearance like the upper glacial"	6
"Gravel at which water rose."	

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GILLINGHAM.—Well at Gillingham Thicks for the Gamekeeper's Cottage.

Communicated by Mr. E. T. DOWSON.

N.B.—The information as to thickness of each deposit was obtained from Mr. Youell, well-sinker, Beccles. I compared the difference of altitude between the shell bed at Aldeby and top of well with aneroid, and found it about 80 feet.

	FEET.
Upper Glacial clay, about	20
White sand	30
Gravel	8
Brickearth ?, if brickearth at all, it is very sandy but contains mica	3
Red sand, silt and gravel, and white sand, to water	8
Black loam	3
	72

HADDISCOE.—South of (exact locality unknown).

Communicated by Mr. D. PALMER to Mr. REID.

Well 87 feet. 35 feet clay, the rest sand. 60 or 70 feet down came to large pieces of wood, said to be oak and alder.

HALES.—Well at the Green. (D. PALMER.)

Depth 60 feet. 30 feet clay.

HALES.—Well at house N. of *l* of Hales Green (on the map).

Measured by Mr. REID.

	FEET.
Boulder clay	12
Clean white sand without stones	22
Brown loam with stones	5
Chalky gravel with water	2
Brown loam, with scattered stones and fragments of *Cyprina Islandica*	12
Sand rather coarser than the Middle Glacial	6
	59

HARDWICK.—The Hall.

Sunk and communicated by Mr. WM. LIMMER to Mr. F. J. BENNETT.

	FEET.
Blue (boulder) clay	60
Sand (water rose 15 feet).	

HARDWICK.—Another well. (F. J. B.)

	FEET.
Clay	22

HARDWICK.—Rose and Crown.

Sunk and communicated by Mr. W. LIMMER. (F. J. B.)

	FEET.
Boulder clay	40
Loam and sand (water rose 5 feet).	

HEDENHAM.—Rectory.

Communicated to Mr. REID.

	FEET.
Ferruginous pebbly gravel	15
Loam	4
Stony brickearth	4
Shingle and sand	16
	39

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HEDENHAM.—Well at Mr. Moore's.

Communicated to Mr. REID.

	FEET.
Clay [boulder clay]	50
Finely laminated brickearth	20
Sand	7
	77

HEDENHAM.—House of Mercy.

Measured by Mr. REID.

	FEET.
Loam	5 or 6
Gravel and sand	55
	60

HEDENHAM.—Brick Kiln.

Communicated by Mr. D. PALMER to Mr. REID.

Well 60 feet. 30 feet clay and 30 feet brickearth.

[Probably incorrect.—C. R.]

HELLESDON.—Asylum, on the Reepham Road, near Drayton.

		FEET.
[Lower Glacial.]	Brickearth	6
[Crag.]	Gravel and sand	24
Chalk		45
		75

Water line stands at about 70 feet down : all sunk.

H. B. W.

HEMPNALL.—Well at the Green.

Communicated by Mr. PALMER to Mr. REID.

Depth 70 feet. 30 or 40 feet clay.

HETHEL.—Parsonage.

Sunk and communicated by Mr. JAMES BANHAM to Mr. F. J. BENNETT.

	FEET.
Boulder clay	45
(Water rose 8 feet).	

HORSFORD.

I was informed that the well at the mill, Horsford Heath, was sunk through more than 40 feet of brickearth, the lower part of which was full of "dodmans," bits of marl or chalk.

H. B. W.

ST. JOHN ILKETSAL.—Well at the new houses on the Halesworth Road.

Communicated by Mr. LAWRENCE to Mr. REID.

Sixty feet of clay, water within 25 feet of the surface.

ST. JOHN ILKETSAL.—Rectory. (C. REID.)

	FEET.
Clay and brickearth, about	6
Sand	34
	40

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KESWICK.—The Hall.

Well, 80 feet deep.

KIRBY BEDON.

Well at cottage by junction of lanes north-east of church.

		Feet.
Chalky Boulder Clay		20
[Norwich Crag.]	Gravel and sand	33
		53

H. B. W.

LAKENHAM.—Long John's Road Brickyard.

Well, 100 feet in depth.

KIRBY CANE.—Well at farm 30 ch. N. of the Church.

Measured by Mr. REID.

	Feet.
Clay, with chalk, flints, &c.	40
Sand, fine white	8
Stony clay	9
White sand, with a few pebbles and occasional pieces of clay	18
Do. more pebbly	2
Brickearth, with small pieces of chalk	1¼
Sand, with scattered stones, as above	2
Brickearth, with scattered stones, angular, sub-angular, and pebbles, no bedding	10
Sand, with occasional balls of blue loamy clay (sand evenly bedded)	1
Pebble gravel	19¾
	111

MARSHAM.—Rippon Hall.

Communicated by Mr. F. SUTTON to H. B. W.

		Feet.
Lower Glacial	Loose sandy gravel	6 to 8
	Brickearth	25
Upper Crag.	Contorted sands and gravel	10 to 12
Chalk.		

METTINGHAM.—The Castle. (D. PALMER.)

Well, 90 feet (no details given).

MOURNING THORPE.—Boyland Hall. (D. PALMER.)

Well, 40 or 50 feet; 20 feet clay.

NORWICH.—Messrs. J. and J. Colman's Carrow Works. Situated within a few yards of the River Wensum.

		Feet.	
	Alluvium		12
Chalk	Hard chalk, with flints at distances of about 6 or 7 feet apart (483 feet ?)	500	1152
	Soft chalk, like white lead and of a rusty colour	10	
	Hard chalk as before (above)	190	
	Hard chalk, with flints about 4 feet apart	350	
	Chalk without flints	102	
	Upper Greensand		6
	Gault (not passed through)		36
			1,206

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At this depth "an accident to the machinery took place, and the boring was "not further prosecuted."

The total thickness of the Chalk is given on the authority of Mr. C. B. Rose. He says, "the Chalk with flints is said to be 1,050 feet thick; the Chalk without "flints 102 feet; and I am quite disposed to rely upon the authority of the en- "gineer, having questioned him very rigidly and found him a well-informed "man upon the subject." Proc. Geol. Assoc. vol. i., No. 8, 1862; *see* also Geol. and Nat. Hist. Repertory, 1879, p. 257.

The details of the strata are given on the authority of the Rev. J. Crompton. He however estimated the upper division of Hard Chalk at 483 feet.

Geologist, vol. v., p. 461. *See* also Rep. Brit. Assoc. Trans. of Sects., p. 70.

For list of fossils obtained from the boring, *see* p. 7.

In the MS. Section-Book (of Wells) in the Geological Survey Office this well is thus noted:—

1862.

	Feet.
Alluvium	12
Chalk	1,030
Upper Greensand	16
Gault	36
Lower Greensand (water).	
	1,094

This account is noted in the "Guide to the Geology of London" by Mr. Whitaker, and differs only from the one overleaf in making the Chalk 122 feet less.

Mr. Crompton mentioned that there were two wells, one of which was 775 ft. deep.

In the *Sixth Report of Commissioners on Water Supply*, 1874, it is also stated that the well at Messrs. Colmans' (1868) was sunk as follows:—

	Feet.
Alluvium Chalk	400

NORWICH.—Well boring. Messrs. Hills and Underwood's Distillery.

Recorded by Mr. GUNN (Norwich Geol. Soc., 6th April 1875).

		Feet.
42 feet	Made earth	3
	Sand	2
	Silt with shingle and river-mud, at 2 feet from the base of which a human skull was said to have been found	37
	Chalk pierced	228
		270

NORWICH.

Mr. S. W. Utting informed me that the ground beneath Gurney's Bank was found during alterations, to be honey-combed with wells, some apparently only 10 or 12 feet in depth.

H. B. W.

NORWICH.—Messrs. J. B. and H. Morgan's Brewery.

Section by T. CLARK.

Sunk about 35 feet, the rest bored.

	Feet.
Made earth	about 12
Chalk with flints	„ 218
	230

H. B. W.

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NORWICH.—Messrs. R. Bullard and Sons, Anchor Brewery.

Well, 35 to 40 feet deep, in Chalk.

H. B. W.

NORWICH.—Messrs. Youngs, Crawshay, and Youngs' Brewery.

Well about 300 feet in depth. Water found at all depths. Level about 10 feet beneath surface. Does not sink above 3 or 4 inches when they are pumping, and afterwards regains its ordinary level in a few minutes.

H. B. W.

NORWICH.—Messrs. Steward, Patteson, Finch, and Co., Pockthorpe Brewery.

Communicated by Mr. A. FERRABY.

"Supply unlimited."

	FEET.
Alluvium	20
Chalk	230
	250

H. B. W.

NORWICH.—Well at the Rosary Cemetery.

	FEET.
Brickearth, Sand and gravel	50
Chalk	50
	100

H. B. W.

NORWICH—Ber Street, by Church.

80 feet to chalk (including 10 feet of brickearth).

(GIDNEY.)

NORWICH.—Mousehold, by Brickyard near centre of Common.

Well, 110 feet, into Chalk.

Kett's Castle Villa (built by J. B. Ladbrooke).

Well, 160 feet, into Chalk.

H. B. W.

NORWICH.—Mousehold, Mr. John Harvey's.

Communicated by Mr. LAWRENCE to Mr. REID.

	FEET.
Sand and gravel	60
Chalk	100
	160

NORWICH.—Section of a Well at a farm upon Mousehold.

R. C. TAYLOR, Geol. of East Norfolk, p. 17.

	FEET.
Diluvial gravel and sand	88
Conglomerated crag shells	2
Chalk	42
	132

PLUMSTEAD.—Farm nearly opposite the old racecourse at Plumstead.

Mentioned by J. E. Taylor at meeting of Norwich Geol. Soc., Nov. 7, 1871 (Norfolk News).

Bed of shells at depth of 80 feet.

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LITTLE PLUMSTEAD.—By road between Plumstead Street and Norwich, on the eastern side of East Norfolk Railway.

Brickearth about 30 feet, sandy at top.

H. B. W.

PORINGLAND.

I was informed by Mr. J. T. TODD that a Mastodon's tooth was obtained at the bottom of the well. The specimen is preserved in Gurney's Bank.

H. B. W.

RINGSFIELD.—Well at.

Clay, 52 feet + (water from a land spring).

C. REID.

SHIPMEADOW.—Rectory.

	FEET.
Clay - - - - - - -	about 25
Sand and gravel - - - - - - -	„ 35
	60

C. REID.

SHIPMEADOW.—House of Industry.

	FEET.
Clay - - - - - - - -	12
Gravel, &c. - - - - - - -	about 70

C. REID.

SPIXWORTH.—Red brick cottage south-west of *p* of Spixworth (on the map).

	FEET.
Pebbly gravel Chalk } - - - - - - -	27

H. B. W.

STOCKTON.—Black Boy Inn. (D. PALMER.)

Well, 87 feet, all sand.

Includes about 10 feet of clay according to Mr. LAWRENCE.

C. REID.

SPROWSTON.—For John Gurney, Esq.

Sunk and communicated by MESSRS. LEGRAND and SUTCLIFF to Mr. W. WHITAKER.

	FEET.
Sand - - - - - - - -	28
Chalk, very pure water, full of small shells - - -	83
	111

SPROWSTON.—Heath Farm.

Gravel about 30 feet.

H. B. W.

SPROWSTON.—Gunnell's Brickyards.

Wells sunk 70 or 80 feet into Chalk. (*See* p. 98).

H. B. W.

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STOKE HOLY CROSS.

Communicated by Miss SCOTT, of Bungay, to S. WOODWARD, MS. 1825.

	FEET.
Diluvial and Tertiary; at which depth a bed of Crag shells was cut through consisting of *Cardium edule, Murex* [=*Purpura lapillus*?], *Trophon carinatus* [=*T. antiquus*], *Turbo* [=*Litorina*] *litorea, Venus æqualis* [=*Cyprina Islandica*], *Mya arenaria, Tellina obliqua.* Bones of deer? and vertebræ of *Platax* - - - - -	100
Clay and Chalk in which no organic remains were found - -	170
	270

STRATTON ST. MICHAEL.—Well at farm east of *O* of Roman (on the map).

	FEET.
Boulder Clay - - - - -	33
[Crag.] Pebbly gravel.	

See also p. 127.

H. B. W.

TAVERHAM.—"Times" Paper Mill, 1868.

Noticed in *Sixth Report of Commissioners on Water Supply*, 1874.

	FEET.
Alluvium } Chalk } - - - - - - -	150

THARSTON.—Rectory.

Sunk, and communicated by Mr. GEO. BANHAM to Mr. F. J. BENNETT.

	FEET.
Boulder Clay - - - - - - -	50
Gravel and sand - - - - - - -	6
(Water rose 6 feet.)	
	56

THWAITE-NEXT-LODDON.—Hall.

Communicated by Mr. D. PALMER to MR. REID.

Well, 100 feet; 30 or 40 feet clay, the rest sand.

WRENNINGHAM.—Mr. Stannard's.

Sunk, and communicated by Mr. JAS. BANHAM to Mr. F. J. BENNETT.

	FEET.
Washed sea sand - - - - - -	20

WRENNINGHAM.—Mr. Day's.

Sunk, and communicated by Mr. J. BANHAM to Mr. BENNETT.

	FEET.
Sand and gravel - - - - - - -	20

WRENNINGHAM.—Mr. Batten's cottage.

Sunk, and communicated by Mr. J. BANHAM to Mr. BENNETT.

	FEET.
Black moor - - - - - - -	25

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NATURAL WELLS AND MINERAL SPRINGS.

Burgh Apton.—I was informed by Mr. T. G. Bayfield that a spring of a petrifying nature was to be met with in this neighbourhood. No doubt it derived its calcareous matter from the chalky Boulder Clay.

Costessey.—"Walsams Wells" are here marked on the map. Properly it should be St. Walstan's Well? Blomefield mentions that on Church Farm, a little below Bauburgh Church, there was a healing spring, called St. Walstan's Well. St. Walstan was born at Baber (Bauburgh), and died in Costesseye Wood, and a spring rose at the spot, "contrary to the nature of the place." (Blomefield, fol. ed., vol. i., p. 641.)

Ditchingham.—At the Bath Hills a spring of remarkably cold water was utilized for the bath there erected.

Norwich.—Red Well Street. This is situated in the parish of St. Michael-at-Plea; also "in some old evidences" it is called "St. Michael at Muspole, "that is, *Much-Pool*, there being formerly a *Pool* where the *Red Well* now is." "The *Pond* or *Pool* was filled up when the *Well* was made here, and the *Pump* "was first fixed in 1629." (Blomefield, fol. ed., p. 719.)

"Close by the River on the left hand, going out of *Bishop's* Gate, is a spring of pleasant water, formerly much resorted to." (Blomefield, fol. ed., p. 798.)

Thwaite.—Near the boundary of the parish of Thwaite, and that of Mundham St. Peter (in which is now included that of St. Ethelbert, whose church is in ruins), "Thwaite spring" is marked on the map.

B.—Prospects of Coal.

The possible occurrence of productive Coal-measures beneath the Cretaceous and Oolitic rocks of Norfolk has been pointed out on many occasions by Mr. J. Gunn;* as yet, however, the matter remains a purely speculative one, and inasmuch as the rocks exposed at the surface furnish no clue to the character or arrangement of the Palæozoic rocks beneath, the question can only be settled by boring.

The possibility of the occurrence of Coal-measures, even beneath the area under consideration, receives support from the evidence furnished by borings in other parts of the Eastern Counties. Thus at Harwich a dark bluish-grey slaty rock of carboniferous age, probably of an age immediately antecedent to the Coal-measures, was met with at a depth of 1,029 feet beneath the Eocene beds and Chalk. Under London rocks, classed as Old Red Sandstone or Devonian, have been reached at depths of 1,004 and 1,064 feet; while at Ware in Hertfordshire, Silurian rocks (Wenlock Shale) were touched at a depth of only 800 feet beneath the surface. Moreover in Belgium and the north of France, Coal-measures are found sometimes at depths of only 300 or 400 feet beneath the Chalk and Tertiary strata; and here they are accompanied, seemingly in perfect conformity, by Devonian rocks, like those found under London.

The Palæozoic rocks are frequently so much disturbed, and sometimes even inverted, that no accurate calculations can be made on the probable position of the Coal-measures here or there, from the facts at present made known by our deep borings.

* See list of papers in Appendix.

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The accompanying diagram shows in a general way the evidence made known, and the depth at which the older rocks would be likely to occur in Norfolk. (*See* p. 6.)

Professor Prestwich was disposed to think that the slaty (Carboniferous) rock at Harwich lay on the north side of a coal-basin, in which case the Lower Carboniferous and Devonian beds would rise beyond it and pass under Suffolk. Considering the disturbances before alluded to, we need by no means conclude that Coal-measures are on this account probably absent from Norfolk; on the contrary, the undulations affecting the Palæozoic rocks might very possibly bring in a coal-basin in some portion of this area, as represented on the diagram.

At present, however, no one locality in Norfolk can be mentioned as more likely than another to yield Coal-measures at a workable depth.

Of course, in West Norfolk, whether at Hunstanton, Lynn, or Downham Market, we avoid the Chalk, which we know to be over 1,000 feet at Norwich; but we do not know how thick the Oolitic strata may be in this district, and at Lynn the depth of 680 feet has been reached without passing through them. Whereas in proceeding towards Harwich we know that the Oolitic strata must gradually die out, for at this locality the Cretaceous beds rest directly upon the Palæozoic rocks.

The question can only be settled by public enterprise, because a trial-boring might only indicate where in some other, and perhaps distant, locality coal might with probability be reached, and under such circumstances it is not to be expected nor recommended that any private individual should make the experiment.

Black shale is generally enough to stimulate hope, and a man at Shottesham, probably from the testimony of the rocks in a Boulder-clay pit, told me he knew there was coal in the parish. Not a hundred years ago a trial for coal was made within five miles of Norwich. In his account of Framingham (1820), Dr. Rigby says, "There is a traditionary report also that even coal has been found "here, and some years ago I was induced, in conjunction with the "late James Crowe, Esq., who had some property in the neighbour-"hood, to dig to a considerable depth on a high part of what was "then the heath. Near the surface was gravel, and below it clay, "which continued until water rose and stopped our progress." He mentions the finding of "two isolated pieces of pure coal" in the clay; but these were probably lignite, being "of a texture very different" from the Newcastle coal. When called upon to give some answer concerning the likelihood of getting coal in Norfolk, I always reply in the affirmative, with these saving clauses, that a shaft be sunk deep enough, say 1,000 or 1,500 feet, and that the speculator be fully prepared to find no coal.*

* These remarks are chiefly taken from my address to the Norwich Geol. Soc. in 1879.

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List of Minerals.

Bitter Spar (?) has been found in a Chalk pit near Little Catton.*

Calcite is found in crevices of Chalk or Boulder Clay, and lining the interior of fossils, especially *Ananchytes*.

Annulated Chalcedony (Beekite) has been met with in the Norwich Crag, and an ammonite from the Chalk of Thorpe near Norwich, in the collection of the late Mr. J. King, possesses an incrustation of the same mineral.

Crystals of Quartz often fill cavities in the flint.

Oxides of Iron and Manganese are plentiful in the gravels of the district.

A specimen of Earthy Phosphate of Iron (Vivianite?) from Boyland, near Long Stratton, was many years ago presented to the Geological Society of London by S. Woodward.

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* *See* Squires, On "Thomsonite," Ann. Phil. ser. ii., vol. ii., p. 254; the mineral recorded is said to be composed of carbonates of lime and magnesia.

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APPENDIX.

List of Papers, &c. on the Geology of Norfolk, by William Whitaker, B.A., F.G.S., and H. B. Woodward, F.G.S.

* Works marked thus contain references to the geology of the district described in this memoir.

† Works marked thus contain references to the district described in the memoir on the geology of Cromer, &c.

A list of many topographical works not herein mentioned will be found in "The Norfolk Topographer's Manual," by S. Woodward (revised and augmented by W. C. Ewing, 1842).

In the Proc. Norwich Geol. Soc., vol. i., pp. 4-15, is a list of papers communicated to the Society from the time of its establishment in 1864 until the annual meeting in November 1877. By Stephen W. Utting. This contains some references to newspapers not inserted here.

1659.

† Browne, Sir Thos. Letter to Sir Wm. Dugdale on the head and bones of a very large fish at Hasbro'. (Printed in "Excursions in the County of Norfolk." 1818. Vol. i., p. 121.)

1662.

Dugdale, [Sir] William. The History of Imbanking and Drayning of Divers Fenns and Marshes, Both in Forein Parts, And in this Kingdom; And of the Improvements thereby. London.

[2nd ed. Revised and corrected by C. N. Cole. Fol. London, 1772.]

1664.

* Lawrence, Thomas. Mercurius Centralis; or a Discourse of Subterraneal, Cockle, Muscle, and Oyster-shels, found in the digging a well at Sir William Doylie's, in Norfolk. 12°. London.

(Another edition. 12°. London, 1688.)

1698.

Spelman, Sir H. Icenia. sive Norfolciæ Descriptio Topographica. (Printed in "Reliquiæ.") Fol. Oxford. [Fol. London, 1723, 1727.]

1699.

Allen, B. The Natural History of the Chalybeat and Purging Waters of England. [Aylesham, p. 23.] Small 8vo. London.

[Another edition—The Natural History of the Mineral Waters of Great Britain. 8vo. London, 1711.]

1718.

Le Neve, P. An Account of the Sinking of three Oaks into the ground at Manington, in the county of Norfolk. Phil. Trans., vol. xxx. (No. 355), p. 766.

1728.

* Burnet, Dr. Thomas. *De* Statu Mortuorum et resurgentium *tractatus*. 2nd ed. By M. Earbery. 2 vols.

[Vol. ii., p. 46. Note on Fossil Shells.]

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1729.

* Woodward, Dr. J. An Attempt towards a Natural History of the Fossils of England in a Catalogue of the English Fossils in the Collection of J. Woodward, M.D. 8vo. London.

1739–1775.

* Blomefield, Rev. Francis. An Essay towards a Topographical History of the County of Norfolk. 5 vols. Fol. Fersfield and Lynn.
[Reprinted in 11 vols. 8vo. and 4to. London, 1805–1810.]

1745.

† Baker, H. A Letter concerning an extraordinary large fossil Tooth of an Elephant [from Mundesley, Norfolk]. Phil. Trans., vol. xliii. (No. 475), p. 331. Abridged, vol. x., p. 599.

1746.

* Arderon, W. Some Account of the Sinking down of a Piece of Ground at Horseford in Norfolk. Phil. Trans., vol. xliii. (No. 477), p. 527. Abridged by Martyn, vol. x., pp. 587, 588.

1747.

*† Arderon, W. Extract of a letter to Mr. H. Baker, F.R.S., containing observations on the precipices or cliffs on the N.E. sea coast of the county of Norfolk. Phil. Trans., vol. xliv. (Part 1. No. 481), p. 275. Abridged, vol. x., pp. 589–592.

† —— Part of a Letter concerning the Formation of Pebbles [Norfolk]. Phil. Trans., vol. xliv. (Part 2, No. 483), p. 467. Abridged, vol. x., p. 608.

* Baker, H. A Description of a curious Echinites [from Bauburgh, near Norwich]. Phil. Trans. (Part 2, No. 482), p. 432. Abridged, vol. x., p. 634.

1748.

* Arderon, W. An Account of large subterraneous Caverns in the Chalk Hills [Mousehold], near Norwich. Phil. Trans., vol. xlv. (No. 486), p. 244. (*See also* vol. xlix., p. 380.) Abridged, vol. x., p. 593.

1749.

Baker, D. E. A letter containing Considerations on two extraordinary Belemnitæ [Norfolk]. Phil. Trans., vol. xlv. (No. 490), p. 598.

1774.

Ives, John. Remarks upon the Garianonum of the Romans; the Site and Remains fixed and described. 12mo. London.
[Fossil shells, pp. 9, 10.]

1781.

Elliot, Dr. J. An Account of the Nature and Medicinal Virtues of the Principal Mineral Waters of Great Britain and Ireland. 8vo. London.
(Aylesham, p. 127; Thetford, p. 270.) (2nd ed., 1789.)

1787 and 1795.

* Marshall, W. The Rural Economy of Norfolk (vol. i.; Soils, pp. 11–15; Chalk Marl, Chalk, &c., pp. 18–27). 2 vols. 8vo. London.

1791.

Armstrong, M. J. An Essay on the Contour of the Coast of Norfolk; but more particularly of the Marum-Banks and Sea-Breaches, so loudly and so justly complained of. 4to. Norwich.

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1792.

† BROGRAVE, Sir B. Account of Sea-Breaches between Yarmouth and Happisburgh. 4to. Norwich.

PENNANT, T. Introduction to the Arctic Zoology. 2nd ed. 4to. London.
(Introduction, Norfolk, p. 8.)

1794.

PAGE, Sir T. H. Reports on the Draining of the Fens. 8vo.

1796.

* KENT, N. A General View of the Agriculture of the County of Norfolk; with Observations for the Means of its Improvement. 8vo. Norwich.

1798.

WISEMAN, B. Account of a substance found in a Clay-pit; and of the Effect of the Mere of Diss upon various Substances immersed in it. With an Analysis of the Water of the said Mere by C. HATCHETT. Phil. Trans., vol. lxxviii., p. 567; and in Journ. Nat. Phil. Chem. and Arts, vol. iii., p. 77. (4to. 1799.)

1800.

† BARTELL, E., jun. Observations upon the Town of Cromer, considered as a Watering Place, and the Picturesque Scenery in its neighbourhood. 8vo. Holt.
[2nd ed. Title altered. 1806. 8vo. London, pp. 124.] (Map and views.)

1804.

GRISENTHWAITE, J. Reffley Spring. 8vo. Lynn.

1804–11.

* PARKINSON, J. Organic Remains of a former World. 3 vols. 4to. London.

1804.

* YOUNG, A. A General View of the Agriculture of the County of Norfolk; drawn up for the Consideration of the Board of Agriculture and Internal Improvement. 8vo. London.
[Map and Account of Soils.] (2nd ed. 1813?.)

1806–1824.

LYSON, DANIEL, & SAMUEL. Magna Britannia, being a concise Topographical Account of the several Counties of Great Britain. 6 vols. 4to.
[Natural History of Norfolk, pp. 361–365.]

1806.

SMITH, W. Observations on the Utility, Form, and Management of Water Meadows, and the draining and irrigating of Peat Bogs. 8vo. Norwich.

1810.

EVANS, Rev. J., and J. BRITTON. The Beauties of England and Wales. 8vo. London.
[Norfolk. Physical Geography, Minerals, Fossils, Agriculture, vol. xi., pp. 73–106.]

N.D., about 1810.

SMITH, WM. A Description of Norfolk. 8vo. Norwich.
[Only 56 pages were printed. S. WOODWARD.]

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N.D. [1812.]

COOKE, G. A. Topographical and Statistical Description of the County of Norfolk. 12mo. and 8vo. London. (Agriculture and Soils, pp. 129–134.)

1812.

RICHARDS, W. The History of Lynn, from the earliest Accounts to the Present Time; to which is prefixed a copious Introductory Account of its Situation, Harbour, Rivers, Inland Trade, and Navigation, the Ancient and Modern State of Marshland, Wisbeach, and the Fens. 2 vols. 8vo. Lynn.
[Quotations from Dugdale and Sir T. Browne.]

1812–29.

* SOWERBY, J. The Mineral Conchology of Great Britain. 6 vols. 8vo. London.

1815.

* SMITH, W. A Geological Map of England and Wales.
—— A Memoir to the Map and Delineation of the Strata of England and Wales, with part of Scotland. 4to. London. [Norfolk, p. 15.]

1816.

* —— Strata identified by Organized Fossils. 4to. London.

1817.

* BUCKLAND, Rev. Prof. W. Description of the Paramoudra, a singular fossil body that is found in the Chalk of the North of Ireland; with some general observations upon Flints in Chalk, tending to illustrate the History of the Formation. Trans. Geol. Soc., vol. iv., p. 413.

1817, 1818.

RIGBY, Dr. E. Holkham, its Agriculture, &c. 8vo. Norwich.

1817.

* SMITH, W. Stratigraphical System of Organized Fossils. 4to. London.

1818.

ANON. Fossil bone of a Whale. (Roydon, near Diss.) Journ. of Sci. and Arts, vol. v., p. 140.

CUBITT, W. Report upon a Plan for making the River from Norwich to Yarmouth navigable for sea-borne vessels; with a Plan, showing the depths of the River from the Foundry Bridge to Yarmouth Bridge. 8vo. Norwich.

MANNING, Rev. H. C. An Analysis and Brief Account of the Thetford Mineral Waters; translated from the Latin Original of the late Matthew Manning, M.D., of that place. 8vo. Thetford.

1819.

ACCUM, F. A Guide to the Chalybeate Spring at Thetford, exhibiting the general and primary effects of the Thetford Spa . . . . and a Sketch of the History and present State of Thetford. 12mo. London.
(Analysis in Phil. Mag., vol. liii., p. 359.)

*† SMITH, W. Geological Map of Norfolk.

* —— Geological View and Section of Norfolk. [Lynn to Yarmouth.]

1820.

BAILEY, H. W. A Letter to the Committee of the Thetford Mineral Spring Company, with the First Report, &c. 12mo. Thetford.

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* Rigby, Dr. E. Framingham, its Agriculture, &c., including the Economy of a small Farm. 8vo. Norwich.
[Notes on Fossils, p. 47.]

† Stevenson, G. Observations on the Bed of the German Ocean or North Sea. Edin. Phil. Journ., vol. iii., p. 44.

1821.

Cubitt, W. The Second Report to the Committee appointed for taking into consideration the best means of making Norwich a Port, &c. 8vo. Norwich.

* Squires, P. On Thomsonite. Ann. of Phil., ser. 2, vol. ii., pp. 254, 255.

1822.

Conybeare, Rev. W. D., and W. Phillips. Outlines of the Geology of England and Wales. 8vo. London.

† Taylor, R. [C.]. Fossil Bones on the Coast of East Norfolk. Phil. Mag., vol. lx., pp. 132–135.

* Telford, T. The Report on the Proposed Improvement of the Navigation to Norwich. 8vo. Norwich.

1823.

Buckland, Rev. Prof. W. Reliquiæ Diluvianæ. [Norfolk, pp. 173, 192, 193.] 4to. London.

Taylor, R. [C.]. Geological Section of Hunstanton Cliff, Norfolk. Phil. Mag., vol. lxi. pp. 81–83.

1824.

* Parkinson, J. Outlines of Oryctology; an Introduction to the Study of Fossil Organic Remains. 8vo.

† Taylor, R. [C.]. Remarks on the Position of the Upper Marine Formation exhibited in the Cliffs on the north-east Coast of Norfolk. Phil. Mag., vol. lxiii., p. 81.

* —— On the Crag Strata at Bramerton, near Norwich. Trans. Geol. Soc., 2nd ser., vol. i., pp. 371–373.

* —— On the Alluvial Strata and on the Chalk of Norfolk and Suffolk, and on the Fossils by which they are accompanied. *Ibid*, pp. 374–378.

1826.

*† Robberds, J. W., jun. Geological and Historical Observations on the Eastern Vallies of Norfolk. 8vo. London and Norwich.

Abstract of the Minutes of Evidence taken before a Committee of the House of Commons . . . on the Bill for making a Navigable Communication between . . Norwich . . and Lowestoft . . 8vo. Norwich.

1827.

* Featherstonhaugh, G. W. Account of an excavation in the Chalk at Norwich. Proc. Geol. Soc., vol. i., p. 35.

† Layton, Rev. J. Account of the Fossil Remains in the neighbourhood of Harborough [Hasborough, Norfolk]. Edin. Journ. of Sci., vol. vi., pp. 199–201.

* Robberds, J. W. Reply to Mr. R. C. Taylor's Remarks on the Hypothesis of Mr. Robberds on the former Level of the German Ocean. Phil. Mag., ser. 2, vol. ii., pp. 192, 271.

† Taylor, R. [C.]. Notice respecting the Appearance of Fossil Timber on the Norfolk Coast. Trans. Geol. Soc., ser. 2, vol. ii., p. 327.

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*† Taylor, R. [C.]. On the Geology of East Norfolk; with Remarks upon the Hypothesis of Mr. Robberds, respecting the former Level of the German Ocean. Phil. Mag., ser. 2, vol. i., pp. 277, 346, 426.
(Reprinted, with additions, together with the two following papers. 8vo. London, 1827.)

*† —— On the Natural Embankments formed against the German Ocean, on the Norfolk and Suffolk Coast, and the Silting up of some of its Æstuaries. *Ibid*, p. 295.

*† —— On the Geological Features of the Eastern Coast of England; and concluding Remarks on Mr. Robberds' Hypothesis. *Ibid*, p. 327.

1828.

* Robberds, J. W. Historical and Geological Descriptions in J. Stark's "Scenery of the Rivers of Norfolk, comprising the Yare, the Waveney, and "the Bure." 4to. Norwich. (Another edition in 1834. Fol.)

Rose, C. B. On the Organic Remains of the Diluvium in Norfolk. Quart. Journ. of Sci., Lit., and Art, p. 308.

[In this paper reference is by mistake made to a former paper that was not published. C. B. Rose in letter to S. Woodward, Feb. 5, 1829.]

1829.

* Rose, C. B. On the Anatomy of the Ventriculites of Mantell. Mag. Nat. Hist., vol. ii., pp. 332–341.

* Stock, D. Fossil Shell attached to Flint, &c. [Ditchingham.] Mag. Nat. Hist., ser. 1, vol. i., p. 69.

*† Woodward, S. The Geology of Norfolk in J. Chambers' "A General "History of the County of Norfolk, intended to convey all the Information of "a Norfolk Tour." 2 vols. 8vo. Norwich.

† —— A letter [to Dr. Fitton] respecting some remarkable Fossil Remains found near Cromer, in Norfolk. Proc. Geol. Soc., vol. i., p. 93.

1830–1833.

*† Lyell [Sir], C. Principles of Geology, vols. i.–iii. 8vo. London.
(Many later editions.) (Vol. iii., Crag, pp. 171–182.)

Sedgwick, Rev. Prof. A. On the Classification of the Strata which appear on the Yorkshire Coast. Ann. Phil., 2nd ser., vol. xi., pp. 339–362.
(Hunstanton, p. 342.)

1830.

* Woodward, S. A Synoptical Table of British Organic Remains. 8vo and 4to. London.

1831.

* Woodward, S. A Copy of an Ancient Plan of the Chalk Vaults near St. Giles' Gates, Norwich; made by John Bond, 1571. Archæologia, vol. xxiii., p. 411.

1832.

* Woodward, S. Origin of the Crag Stratum of Norfolk. Mag. Nat. Hist., vol. v., p. 544.

1833.

Anon. The Storm; with Reflections and Admonitions on its disastrous Effects upon the Norfolk Coast. 8vo. Norwich.

* Layton, Rev. J. Notes on the Geology of Norfolk, pp. 280–286, 369–372 of G. Fairholme's "A General View of the Geology of Scripture." 8vo. London.

* Woodward, S. An Outline of the Geology of Norfolk. 4to and 8vo. Norwich.

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1834.

PAGET, C. J. and J. Sketch of the Natural History of Yarmouth and its neighbourhood. (Geology by S. WOODWARD, pp. iv–vi.) 8vo. London.

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INDEX.

A.

Abbott, A. R., 189.
Accum, F., 174.
Acle, 2, 66, 100, 119, 148.
Adams, Prof. A. L., 198, 201, 203.
Ætites, 28, 38.
Agriculture and Geology, 30, 91, 92, 117.
Alburgh, 117, 127.
„ Street, 91.
Aldeby, 34, 36, 39, 40–56, 86, 88, 126, 141, 145, 161, 189, 190, 199.
Aldeby Beds, 86.
Alder Car, Stratton, 70.
Alderson, Dr., 148.
Alexander, Capt. H., 40, 55, 178, 179, 182.
Allen, B., 171.
Alluvial Deposits, 4, 141.
Alluvium, 141, 144, 153.
Almack, B., 180.
Alphington, 124.
Alston, E. R., 196.
Amyot, T., 147.
„ T. E., 20.
Analyses of strata, 94, 121.
Annis Hill, 128.
Ant, River, 2.
Anticlinal in Chalk, 134–136.
Archbold, Dr. G., 197.
Arderon, W., 82, 81, 121, 124, 125, 138, 139, 147, 172, 200.
Area, Physical features of the, 1.
Arminghall, 36, 38, 72, 80, 104.
Armstrong, M. J., 172.
Ashby, 125.
„ Hall, 120.
Ashman's, 88, 109, 110.
Ashwell Thorpe, 104, 123, 129, 131.
Astarte borealis, Zone of, 82.
Attoe's Pit, Catton, 30, 67, 72, 96.
Attlebridge, 38, 66, 118.
Austin, Major T., 187.

B.

Baber. *See* Bauburgh.
Bacon, R. N., 114, 179.
Baculite pit, 8.
Bailey, H. W., 174.
„ Rev. J., 104.
Baker, D. E., 172.
„ H., 137, 172.
Bakewell, R., 177.
Ball, Dr. 144,
Banham, G., 167.
„ J., 162, 167.
Banter's Wood, 127.
Barnham, T., 127.
Barrois, Dr. C., 10, 20, 197.
Barsham, 88, 91, 109.
Bartell, E., jun., 173.
Barton, 64, 92, 94, 143.
„ Broad, 4, 143, 144.
Bath Hills, 85, 86, 108, 168.
Bauburgh, 68, 130, 137, 168, 172.
„ Hall, 142.
Bayfield, T. G., 8, 10, 20, 24, 26, 35, 37, 40, 56, 77, 81, 135, 138, 168, 181, 184.
Bayne, A. D., 194.
Bay's Farm, Forncett, 70.
Bear's Grove, 99.
Beardmore, N., 183.
Beccles, 31, 38, 40–54, 88, 109, 128, 133, 141, 153, 156, 157, 201.
Beccles School Farm, 109.
Beck Barn, 93.
Beck Pease Plantation, 68, 130.
Bedingham, 157.
Bee Cross, 118.
Beekite, 37, 170.
Belaugh, 11, 13, 33, 36, 38, 40, 42–53, 60, 64, 191, 197.
Belaugh Broad, 4.
Belemnitella, Zone of, 20.
Bell, A., 43, 56, 192, 194.
„ R., 56, 186, 194.
Belt, T., 196, 197, 198.
Bennett, F. J., 84, 112, 115, 117, 161, 162, 167.
Bergapton. *See* Burgh Apton.
Billockby, 94, 95.
Bishop's (or Bishopford) Bridge pit, 5, 8, 10, 13–17, 19, 28, 30, 73.
Bistley, 141.
Bitmays, 141.
Bitter Spar, 170.
Bixley, 132, 157.
Blackford Hall, 132.
Blackmore, Dr. H. P., 196.
Blake, Rev. J. F., 197.
„ J. H., 35, 60, 66, 77–80, 94, 96, 100–103, 112, 115, 119, 120, 125, 130, 141–144, 198, 199, 202, 203.
Blake's Pit, Bramerton, 36, 42, 83.
Blind Lane, 65.
Blofield, 2, 76, 100.
Blomefield, Rev. F., 28, 125, 141, 147–149, 168, 172.
Blowing sand, 92.
Blue Clay, 110, 114, 125, 130.
Boarded Barn Farm, 108.

Digitized by Google

Boggis, J., 160.
Bonaparte's Island, 89, 128.
Bonney, Prof. T. G., 197.
Boulders, 91, 119, 123, 125, 126.
Boulder Clay, Chalky, 90, 91, 93, 104, 105, 115, 128, 133, 136, 137, 155.
Boulder Clay, Fossils from the, 123.
„ Streak of, 124.
„ Upper and Lower, Relations of, 90, 94, 100, 103, 118, 119.
Bowerbank, Dr. J. S., 179.
Bowthorpe, 68, 98, 142.
Boyland, 170.
„ Hall, 70, 143, 145, 168.
Bracondale, 69.
Bradeston, 77, 100.
Brady, H. B., 186.
„ G. S., 148, 185, 192, 196.
Bramerton, 33–36, 38, 39–55, 74, 82, 117, 124, 147, 175, 178, 190, 192–194.
Brandon, 110, 116, 137, 138.
„ Beds, 91, 138.
Breccia, 106.
Breese, B. S., 199.
Brickearth, 34, 90–92.
„ Laminated, 110.
„ Norwich, 96.
„ Upper and Lower, 97.
Bridgman, W. K., 40.
Bristow, H. W., 35, 196.
Britton, J., 173.
Broads, 1, 3, 143, 146, 148, 149, 195, 197–199.
Brograve, Sir B., 173.
Brooke, 117, 132, 191.
„ Meres, 117, 126.
Broom Covert, 56, 143.
Broome, 86, 107, 127, 157.
Brown, J., 115, 177.
Brown Boulder-clay, 5.
Browne, Sir T., 171, 174.
Brundall, 36, 37, 38, 42–54, 76, 103, 118, 143, 194.
Buckenham, 77, 143, 149.
„ Broad, 4.
Buckenhams, Earsham, 108.
Buckland, F., 197.
„ Rev. Dr. W., 23, 174, 175.
Bugg's Grave, 93.
Bull's Green, 126.
Bunbury, Sir C. J. F., 182.
Bunker's Hill, Earlham, 68.
Bungay, 27, 85, 108, 128, 132, 141, 151, 155, 157, 158.
Bure, River, 2, 176.
„ Valley, 142, 196.
„ „ Beds, 31, 32, 33, 36, 56, 63, 81, 85, 88, 89, 156.
„ „ Beds, Fossils of the, 36, 38, 41.
Burlingham, 92, 100, 117, 119.
„ House, 99.
„ St. Andrew, 119.
„ St. Peter, 2.
„ South, 119, 158.
Burgh, Aylsham, 36.
Burgh Apton, 85, 105, 125, 168.
Burnell, G. R., 183.
Burnet, Dr. T., 58, 171.
Burnt Lane Plantation, 58.
Burrows, G. C., 157.
Busk, Prof. G., 183.
Buxton, 56, 143.

C.

Caister, Yarmouth, 95, 146.
„ St. Edmund, 147.
Caistor, Norwich, 104, 142, 147.
Calcite, 170.
Camden, W., 147.
Cannon-shot gravel, 90, 128.
Cantley, 77, 101, 149, 152.
„ White House, 81.
„ „ Hethersett, 122, 131.
Carboniferous rocks, Possible occurrence of, 5, 6, 168.
Cars, 141.
Carlton, East, 122, 131, 159.
„ St. Peter, 85.
„ Broad, 4.
„ Lodge, 143.
Carpenter, Dr. P., 185.
Carrow, 11, 16, 30, 151, 156.
„ Abbey, 69, 148.
„ Boring, 7, 9, 163.
„ Bridge, 144, 148.
Carter, Dr. H. J., 7, 196.
Casts of shells in flint, 25, 26.
„ ironstone, 32, 56, 61, 67, 68, 75.
Castle Farm, 138.
Cat's Common, 94.
Catfield, 57, 65, 143.
„ Broad, 4.
Catton, 8, 11–16, 19, 20, 24, 30, 38, 67, 72, 96, 116, 170.
Cautley, Sir P. T., 180.
Caux, J. de, 54.
Caverns in Chalk, 28, 172.
Cavities in Chalk, 186.
Cawston, 93.
Cemetery, City, Norwich, 67.
„ Rosary, 165.
Chalcedony, 170.
Chalk, 4, 8, 154.
„ Age of Norwich, 8, 21, 25.
„ Dip of, 9.
„ Glaciated, 9, 134.
„ Marl, 134, 155.
„ Pipes in the, 139.
„ pits, 28.
„ Surface disturbances in, 9, 134.
„ Thickness of the, 9, 163, 164.
„ Fossils of the, 8, 10.
Chalky Boulder Clay, 90, 91, 93, 104, 105, 115, 128, 133, 136, 137, 155.
Chambers, J., 176.
Chapel Hill, 30, 72, 104, 134.
„ Wood, 62.
Chapman's Broad, 4.
Charlesworth, E., 24, 32, 38, 177, 178, 183, 187, 189, 191.
Chedgrave, 85, 93, 105, 132.

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Chester, Rev. G. C., 127.
Chet, River, 2.
Chillesford Beds, 5, 31, 33, 34, 35, 55, 59, 62, 66, 73, 74, 78–84, 88, 89, 97, 103, 110, 133, 155, 156.
Chingle, 31.
Church, Prof. A. H., 184, 197.
Church Towers, Round, 129.
Clapham, R. C., 183.
Clark, T., 164.
Clarke, J. A., 180.
„ Rev. W. B., 178.
Claxton, 84, 85, 125.
Clay, 34, 90, 92, 110, 115, 130.
Clay-ironstone concretions, 38, 84.
„ pebbles, 38, 59, 64, 84.
„ with flints, 25.
Clements' Mill, 118.
Cliona-borings, 25, 41.
Clippesby, 94, 155.
Clowes, Rev. T., 75, 81, 83.
Clunch, 30.
Coal measures, Possible occurrence of, 5, 168.
Coal smut, 92.
Cobbles, 129.
Cockie stream, 3.
Cold Bath House, 108.
Coldham Hall, 152.
Cold Harbour (Ludham), 65.
Colkett, Mr., 140.
Coll, Mr., 58.
Collins, Mr., 58.
Colman, J. and J., 30, 163, 164.
Coltishall, 8, 12, 24, 34, 36, 38, 39, 42–53, 59, 139, 191, 194.
Colney, 68, 121, 122, 130, 142, 143.
Concretions of iron-ore, 38, 84.
Conglomerate. *See* Iron-pan.
Contorted Beds, 112, 116, 118, 137.
„ Drift, 90, 91, 112.
Conybeare, Rev. W. D., 175.
Cony Hill Farm, 64.
Cooke, G. A., 174.
Coopers Farm, 157.
Coprolites, 75.
Costessey, 2, 12, 13, 15, 16, 67, 118, 130, 168.
Costessey Common, 142.
Cottenham Farm, 65.
Crag Formation, 4.
„ Meaning of term, 32.
„ Fossiliferous localities of the, 38.
„ Upper, Use of term, 31, 33.
„ „ Fossils of the, 41.
Cringleford, 69, 90, 122, 130, 134, 144, 145, 150.
Cringleford Hall, 142.
Croll, Dr. J., 196, 197.
Cromer, 91, 103, 124.
Crompton, Rev. J., 7, 164, 184.
Crosskey, Rev. H. W., 196.
Crossway Farm, 106, 126.
Crostwick, 33, 38, 61, 76.
Crow Hall, 93.
Crowe, J., 169.
Crowfoot, W. M., 40, 54, 55, 75, 87–89, 133, 156, 189, 199, 201.
Crown Point, 80, 124.
Cubitt, W., 174, 175.

D.

Dalton, W. H., 89, 133, 156, 202.
Damgate Lane, 100.
Darraw Green, 127.
Darwin, Dr. C., 10, 181, 182.
Daubers, 117.
Davidson, T., 10, 180, 181, 196.
Davies, W., 184, 200, 201.
Dawkins, Prof. W. B., 184, 185, 187, 189, 191, 194, 196, 200–202.
Daws Wood, 106, 126.
Dead Lime, 116, 120, 137.
Denny, H., 144, 182.
Denton, 91, 108, 127, 158.
Denudation of Valleys, 129, 137, 146. *See* Inter-glacial.
Depwade, 2.
Dereham, West, 129.
„ East, 114.
Dip of Beds, 5, 9.
Diss, 6, 112, 154.
Disturbances by glacial action, 112, 116, 118, 137.
Disturbed Chalk, 9, 134.
Ditchingham, 38, 42–54, 85, 86, 103, 108, 132, 141, 158, 168, 176.
Dixon, F., 181.
„ T. I., 144.
Dodmans, 112, 162.
Doggers, 93, 121.
Dogkennel Meadow, 131.
Dove Inn, 113.
Dowker, G., 20.
Downham Market, 169.
Dowson, E. T., 40, 54, 55, 56, 87, 145, 160, 161, 189, 199.
Doylie, Sir W., 71, 171.
Drainage areas, 2, 3.
Drayton, 16, 66, 93, 98, 134, 139, 162.
Drift, Contorted, 90, 91, 112.
„ Glacial, 90.
Dugdale, Sir W., 171, 174.
Duke's Bridge, 85.
„ Farm, 108.
Dulls House, 107.
Duncan, Dr. P. M., 8, 10, 187, 191.
Dunston, 72.

E.

Eagle stones, 28, 38.
Earbery, M., 58, 171.
Earlham, 12–17, 67, 68, 90, 121, 134.
„ Upper Farm, 98.
Earsham, 108, 127, 141, 158, 159.
Eaton, 12, 15, 18, 68, 90, 98, 130, 138, 142, 144, 178.
Economic products, 28, 92, 117, 140, 154.
Edwards, Dr. H. Milne, 10, 181.
Ehrenberg, Prof. C. G., 22, 25, 178.
Elephas primigenius, 128, 133, 138, 144.
Ellingham, 107, 127, 132, 141.

Digitized by Google

Elliot, Dr. J., 172.
Ellis, Sir H., 149.
Eocene Beds, 4, 31, 139.
Erosion of beds, 34, 38. *See also* Denudation.
Etheridge, R., 10, 15, 26, 35, 40, 185.
Evans, Dr. J., 145, 189, 195, 200.
„ Rev. J., 173.
Ewing, J. W., 68, 138, 189.

F.

Fairholme, G., 57, 176.
Falconer, Dr. H., 40, 58, 180, 182, 185, 189.
Featherstonhaugh, G. W., 29, 175.
Felthorpe, 92, 93.
Fennell, G., 199.
Ferraby, A., 165.
Firgrove Pit, 121. *See* Mackie's Nursery.
Fir House, Hellesdon, 96.
Fisher, Rev. O., 37, 39, 121, 134, 136, 138, 139, 148, 186, 187, 189, 191, 199, 202.
Fishley, 101, 120.
Fitch, Robert, 8, 10, 18, 24, 40, 56, 74, 76, 136, 138, 144, 177, 178, 189, 192.
Fitton, Dr. W. H., 177.
Flegg, East and West, 146.
„ Hundred, 148.
Flints, 20, 30.
Flint gravel, 25, 92, 128.
„ „ List of fossils from the, 26.
„ layers, Disrupted, 134.
„ implements, 84, 110, 145.
Flixton, 159.
Flood gravel, 128.
Floods, 149.
Flordon, 9, 70, 115, 123, 159.
Flower, J. W., 187, 191, 195.
„ Prof., W. H., 54, 55.
Fluvio-marine Crag, 31, 35, 36, 74, 83, 89, 156.
Forbes, Prof. E., 17, 20, 180, 181.
Forest Bed Series, 39.
Formations, List of, 5.
Forncett, 9, 38, 123.
„ St Mary, 70, 124.
„ St. Peter, 131.
Fossils of Alluvium, 144.
„ of the Chalk, 8, 10.
„ of Disturbed Chalk, 137.
„ from the Flint gravel, 25, 26.
„ in Glacial Drift, 92, 94, 95, 97, 105, 109, 115.
„ of the Upper Crag, 32, 41, 58–63, 72, 76, 86, 89.
Foulger, Rev. W., 83.
Fox Hole, Saxlingham, 70.
Foxburrow plantation, 69.
Framingham, 159, 169, 175.
„ Earl, 124.
„ Pigot, 124, 132, 159.
Framlingham, 156.
Fransham, Little, 114.
Freethorpe, 102, 112, 119.
Frettenham, 61, 180.
Frewer, Mr., 30, 189.
Freshwater shells from Alluvium, 145
„ from Crag, 35.
Fritton, 145.
Fuller, Dr., 125.
Fuller's earth, 125.
Fulton, H., 181.
Fundenhall, 123.
Furze Hill, Tharston, 9, 21, 69, 127–129, 131, 132.

G.

Galls, 9, 92, 138–40.
Galleries in Chalk, 28.
Gaudry, A., 200.
Gault, 7.
Gedge, Mr. 191.
Geikie, Dr. James, 129, 136, 195, 196, 199, 200, 201, 203.
Geldeston, 86, 126, 159, 160.
Ger, River, 3.
Gidney, E., 75.
Gillingham, 126, 160.
„ Dam, 153.
„ Thicks, 161.
Glacial Beds, 4, 5, 90.
„ Disturbances, 112, 116, 118, 137.
„ Drift, Shells in, 92, 94, 95, 97, 105, 109, 115.
„ Sands, Lower, 33.
„ Beds, Middle, 90–92, 95.
„ „ Upper, middle, and lower, 90, 91.
„ „ Water-bearing strata of, 154.
Glaciated Chalk, 9, 134.
Godwin-Austen, R. A. C., 33, 36, 181, 186, 189.
Grantham, R. B., 4, 148, 191.
Gravel, 31, 90–92, 128, 141.
„ Cannon shot, 90, 128.
„ Plateau, 91, 128, 146.
Green, Rev. C., 179.
Greensand, Upper, 7.
„ Lower, 7.
Greenwell, Canon W., 138, 194.
Greenwood, Col. G., 191.
Greywethers, 91, 93.
Grime's Graves, 138.
Grisenthwaite, J., 173.
Grove House, Thorpe, 99.
„ Pit, Earlham, 67.
Grubb's Haven, 146.
Gun flints, 30, 177, 201
Gunn (Rev.), John, 3, 24, 34, 35, 39, 40, 55–60, 63, 70, 84, 91, 138, 139, 143, 144, 147, 164, 168, 178, 181, 182, 184–202.
Gunn, Mrs., 23.
„ Rev. W., 143.

Digitized by Google

H.

Haddiscoe, 85, 126, 141, 161.
Haggard Street, 57.
Haime, J., 10, 181.
Hales, 93, 106, 126, 161.
Halesworth, 85.
Halvergate, 66, 101, 102, 119, 149, 155.
Hamilton, W. J., 181.
Hamlington, 65, 92, 99, 103, 119.
„ Corner, 100.
Happing Hundred, 148.
Hapton, 70, 103, 123, 124, 129, 131, 132.
„ Hole, 70.
„ West, 91.
Hardley, 105.
„ Cross, 2, 144.
„ Hall, 85.
Hardwick, 117, 127, 161.
Harkness, Prof. R., 191.
Harmer, F. W., 33, 36, 40, 58, 60, 69, 76, 83, 85, 90, 94–96, 98, 100, 106, 116, 121, 124, 134–137, 145, 188, 190–196, 199, 200, 202.
Harper, J. O., 144.
Harrison, W. J., 201.
Harrod, H., 130, 182
Hartcup, Mr., 86.
Hartford Bridge, 8, 10–19, 30, 34, 35, 55, 68, 116, 120, 121, 134, 137, 138, 151, 192.
Hartford Hill House, 120.
Hartlib, S., 125.
Harwich, 168, 169.
Hautboys, 56, 93.
Hasingham, 77, 100.
„ Broad, 4.
Hatchett, C., 173.
Haveringland, 93, 118.
Hawkshaw, Sir John, 3, 153.
Haynford, 61, 93, 143.
Heath Farm, Sprowston, 99, 166.
Heathel. *See* Hethel.
Hébert, E., 182.
Heckingham, 85, 106, 126.
Hedenham, 107, 113, 132, 161, 162.
Heigham, 2, 11, 67, 140, 151, 152, 178.
„ Hill, 29.
Heights, 1, 2, 114.
Hellesdon, 66, 96, 118, 140, 151, 162.
Helmet Stones, 27.
Helsmere Hole, 125.
Hemblington. *See* Hamlington.
Hempnall, 117, 127, 132, 145, 162.
Henham, 85.
Hethel, 117, 122, 162.
„ Bridge, 127.
Hethersett, 90, 122, 130, 131.
Hevingham, 56, 93, 143.
Hewitt, W., 179.
Hickling, 65, 148.
„ Broad, 3, 4, 148.
High Grove, Langley, 105, 125.
Hill House, Heckingham, 106.
Hillington, 84, 125.
Hills, 1.
Hinde, Dr. G. J., 11, 21, 202.
Hobbs Hill Wood, 106.
Holmes, T. V., 140, 203.
Holms (Holmes), 141.
Holverston, 125.
„ Thicks, 83.
Home Cottage, 97.
Honing, 65.
Hooker, Sir Joseph D., 58.
Hor, River, 2.
Horning, 65, 147.
Hornor, C. J., 111.
Horsford, 92, 93, 139, 162, 172.
„ Water, 127.
Horsham St. Faith's, 61.
Horstead, 11, 19, 23, 24, 29, 36, 38, 40, 42–53, 55, 57, 139, 201, 202.
Hoveton, 34, 61.
„ Broads, 4.
„ St. John, 64, 93.
How Hill, 65, 94.
Howe, 105, 112 132.
Hoxne, 111, 145.
Hughes, Prof. T. McK., 198, 207, 204.
Hull, Prof. E., 188, 194.
Hundred Stream, 2.
Hunstanton, 169.
Huxley, Prof. T. H., 185.
Hysterolites, 26.

I.

Icenian, 32.
Ice-sheet, 124.
Ilketsal, St. John, 110, 162.
Implements, Stone, 84, 110, 138, 145.
Ingate, 88.
„ Mill, 128, 133.
Inter- (or Intra-) Glacial Denudation, 111, 124, 137, 138.
Intwood, 69, 116, 122.
„ Hall, 131.
Iron oxides, 170.
„ pan, 31, 56, 68, 74, 75, 80, 81, 88, 113, 132.
Ironstone concretions, 38, 84.
Irstead, 143.
Ives, J., 172.

J.

Jamb, 34.
Jecks, C., 184, 192, 193.
Jeffreys, Dr. J. G., 41.
Jenkins, H. M., 192.
Jenyns, Rev. L., 188.
John's Car, Reedham, 103.
John John's Wood, 109.
Johnson, M. H., 195.
„ Randall, 196, 199.
Jolly's Lane, Acle, 119.
Jones, J., 185.
„ Prof. T. R., 10, 181, 184–186, 193, 195.
„ Sir W., 149, 190.
Judd, Prof. J. W., 188, 193.
Jukes-Browne, A. J., 22, 91, 200–203.

Digitized by Google

K.

Kent, N., 173.
Keswick, 80, 69, 90, 104, 122, 130, 134, 140, 163.
Ket, River, 2.
Ketteringham, 122, 130, 131.
Kett's Castle Hill, 72, 130, 165.
King, E., 130.
„ John, 10, 18, 26, 40, 123, 170.
„ Rev. S. W., 71, 114, 184, 188, 189.
„ Prof. W., 184.
Kingsley, Rev. C., 188.
Kirby Bedon, 36, 38, 42–54, 82, 124, 163.
„ Cane, 107, 127, 163.
„ Green, 127.
Knights, M., 153, 198, 200.
Kitton, F., 7, 11, 21, 24, 190, 191, 194, 195, 200.
Kiln, Roman, 104, 114, 127.
„ Grove, Yelverton, 125.

L.

Lakeford, 77.
Lakenham, 2, 38, 69, 98, 120, 138, 163.
Laminated Beds, 31, 34, 35, 38.
„ Brickearth, 110.
Lammas, 56.
Land shells from Alluvium, 145.
Langley, 93, 105, 125, 142.
Lankester, Prof. E. Ray, 58, 184, 192, 193.
Lawrence, T., 71, 171.
„ Mr., 157–159, 162, 165, 166.
Layton, C., 104, 142.
„ Rev. J., 55, 57, 175, 176.
Lee, J. E., 203.
Lee-Warner, Rev. H. J., 197.
Leek Hill, 107.
„ Wood, 127.
Legrand, Mr., 156, 166.
Leiodon, 8.
Le Neve, P., 171.
Limmer, W., 161.
Limpenhoe, 78, 102.
Ling's Cover, 66.
Lingwood, 100, 117, 119.
Litcham, 136.
Little Switzerland, 29, 58.
Lives Heath, 105.
Loam, Stony, 90, 91, 112.
„ *See* Brickearth.
Lockwood, W. H., 159.
Loddon, 85, 93, 105, 126, 142, 143.
„ Hall, 105, 106.
Lodge Common Planting Pit, 64.
Lollard's Pit, 5, 8, 30, 73. *See also* Bishop's Bridge.
London Basin, 4.
„ Clay, 31.
Long Acre plantation, Stratton, 70.
„ John's Road, Norwich, 98, 103, 163.
Long Stratton, 69, 117, 170.
Lothingland, 146.
Low End, 70, 123.
„ Farm, Beccles, 110.
„ „ Saxlingham, 70.
Lowe, Dr. J., 190.
Lowry, J. W., 190.
Lubbock, Sir John, 185.
„ Rev. R., 148.
Ludham, 34, 65, 92, 94, 143.
„ Bridge, 144.
Lupton, W. M., 184.
Lycett, Dr. J., 195.
Lyell, Sir Charles, 23, 24, 32, 35, 40, 44, 54, 56, 61, 75, 81, 86, 92, 140, 147, 176–179, 184, 193.
Lynn, 169.
Lyson, D., 173.
„ S., 173.

M.

McCoy, Prof. F., 180.
Mackie, S. J., 184.
Mackie's Nursery, 90, 93, 116, 120, 125.
Magdalen Chapel, Sprowston, 13, 18, 68, 97.
Mammaliferous Crag, 32, 38.
„ Stone-bed, 31, 39, 70, 75, 139.
Mammoth, 128, 133, 138, 144.
Manganese oxides, 170.
Mann, R. J., 179.
Manning, Dr. M., 174.
Manor House, Chedgrave, 105, 132.
Mantell, Dr. G. A., 23, 182.
Margate Chalk, 20.
Markshall, 72, 104, 122, 138, 144.
Marl, 28, 34, 91, 115, 117.
Marsh lands, 146.
Marshall, W., 172, 201.
„ Mr., 152.
Marsham, 38, 56, 93, 163.
Martin, Capt. J. B., 178.
Mastodon, 39, 40, 55, 57, 84, 166, 189.
Maw, G., 35, 90, 93, 188, 192.
Mayton, 57.
„ Bridge, 56.
Melton, Little, 68, 121, 122, 130.
Meres, Brooke, 117, 126.
Mergin, 117.
Mettingham, 108, 128, 163.
Middleton, John, 40, 56.
Mile End, Norwich, 121.
„ Stone Covert, 118.
Miller, S. H., 145, 209.
Milne-Edwards, Dr. H., 10, 181.
Minerals, List of, 170.
Mineral Springs, 168.
Mitchell, Dr. J., 177, 178.
„ W. S., 196.
Moraine profonde, 124.
Morant, A. W., 139, 140, 144, 155, 185, 193, 208.
Morris, Prof. J., 10, 17, 24, 115, 124, 179, 180, 181.

Digitized by Google

Mosasaurus, 8, 19.
Moulton, 78, 90, 101, 119, 130.
Mourning Thorpe, 127, 132, 163.
Mousehold, 4, 25, 27, 30, 38, 90, 96–98, 105, 130, 165, 172.
Moxon, C., 178.
„ Rev. G. B., 179.
Muck Fleet, 2.
Mudgin, 117.
Mulbarton, 117, 131.
Mundham St. Peter, 85, 105.
Munford, Rev. G., 147, 149, 179, 180, 185.
Murchison, Dr. C., 189.
„ Sir R. I., 188.
Murray, J., 183.

N.

Nall, J. G., 117, 140, 186.
Nathorst, A., 196.
Neatishead, 64, 141.
„ Burnt Fen, 4.
Neolithic Implements, 84, 145.
Newfound, 122.
Newton Flotman, 16, 38, 71, 113, 117.
„ Hall, 71.
Newton, Prof. A., 184.
„ E. T., 10, 19, 40, 59, 60, 69, 70, 200–203.
Nogdam End, 85.
Norfolk Crag, 33.
Norris, Mr., 143.
Norton, H., 23, 37, 80, 198–200, 203.
Norton (Subcourse), 85, 106.
Norwich, 2–19, 26–30, 67, 69, 72, 90, 98, 121, 130, 134, 136, 138–144, 146–148, 169, 174–176, 190, 192, 193, 195, 197, 201, &c.
Norwich Brickearth, 96.
„ Chalk, Age of, 8, 21, 25.
„ „ Fossils, 8, 10.
„ Crag, 5.
„ „ First use of term, 32.
„ „ Fossils of the, 32, 41–56, 58–63, 72, 76, 86, 89.
„ „ Relations of, to Glacial Beds, 38, 90, 104.
„ „ Series, 5, 31, 154.
„ Floods in, 150–153.
„ Cemetery, 67, 165.
„ Sewer Works, 124, 139, 144, 155.
„ Springs at, 168.
„ Union Workhouse, 67.
„ Water supply of, 155.
„ Wells in, 163–165.
Nyst, H., 178.

O.

Oakland House, Cringleford, 69, 134.
Oby, 120.
Ochre, 84, 140.
Oliver Broad, 4.
Oolitic Rocks, 169.
Orfeur, J., 198.
Owen, Prof. R., 10, 56, 179–181, 183, 186, 192.
Oxnead, John of, 147, 149.

P.

Page, Sir T. H., 173.
Paget, C. J., 177.
„ [Sir] J., 177.
Palæolithic Implements, 110, 111, 145.
Palæozoic Rocks, 6, 168, 169.
Palmer, C. J., 195.
„ D., 157–163, 167.
Pan, Iron, 31, 56, 68, 74, 75, 80, 81, 88, 113, 132.
Panxworth, 65, 90.
„ Stream, 2.
Paramoudras, 22, 129, 174, 178, 203.
Park Farm, Burgh Apton, 85.
Park Farm, Hevingham, 56.
Parker, J. H., 129.
„ W. K., 184, 186, 195.
Parkinson, J., 23, 28, 32, 39, 175.
Peafield, Norwich, 98.
Peat, 141, 143.
Peaty Mill Dam, 4, 65.
Pebbly sands and pebble beds, 31, 63, 78.
Pedham, 4, 65.
Pengelly, W., 184, 197, 202.
Pennant, T., 173.
Penning, W. H., 22, 90, 115, 116, 135, 198.
Petrified kidneys, 129.
Petrifying spring, 168.
Pewter Hill, 127.
Phillips, Prof. J., 33, 38, 179, 182–184.
„ J. A., 203.
„ W., 175.
Pholas-borings, 35, 39, 76, 81, 83.
Physical Features, 1.
„ Geography, 146.
Pightling, W., 57.
Pipes, 9, 116, 134, 138–140.
Pit-dwellings, 130.
Pitt, R. C., 55, 56, 61, 65, 75, 81, 178, 179.
Plateau Gravel, 90, 91, 146.
Playfair, Dr. L., 94, 180.
Pliocene, 4, 31.
Plumstead, 90, 92, 103, 165.
„ Great, 118.
„ Little, 75, 99, 166.
„ Hall, 99.
„ „ (Blofield), 100.
„ Stream, 3.
„ Street, 75, 99.
Pockets, Sandy, in Chalk, 136.
Pockthorpe, 4.
Poringland, 1, 25, 55, 113, 114, 116, 132, 166.
Post-glacial, 128.
Postwick, 2, 12, 13, 15, 18, 33, 34, 38, 39, 41–55, 75, 103, 113, 136, 142, 151.

Digitized by Google

Postwick grove, 144.
„ Hall, 142.
Pot-stones, 22, 129, 174, 178, 203.
Potter Heigham, 65.
Prestwich, Prof. J., 5, 31, 33, 36, 37, 40, 55, 59, 60, 62, 73–75, 82, 111, 154, 169, 183, 193, 194, 203.
Prigg, H., 188, 192, 203.
Puddingstone, 70, 85.
Pulham, 117.

Q.

Quartz, 170, 107.
Quill, T. M., 156.
Quinton, J., jun., 153.

R.

Race, 107, 112.
Rackheath, 38, 42–53, 61–63, 99.
„ Kiln, 24.
Raveningham, 106, 113, 126.
Railways, Beccles to Ipswich, 133.
„ Norwich to Cromer, 64, 75, 99, 118, 143.
„ Norwich to Ipswich, 72, 98, 104, 123, 131.
„ Norwich to Wymondham 121, 131, 138.
„ Norwich to Yarmouth, 75–77, 79, 102, 103, 118, 141.
„ Trowse loop-line, 69, 120.
„ Waveney Valley Line, 85, 141.
„ Wroxham to Reepham, 56, 57, 60, 93.
„ Wymondham and Forncett branch, 70, 104, 123, 124, 129.
„ Yarmouth and Stalham, 65.
Rainthorpe Hall, 142.
Ramsay, Prof. A. C., 200.
Rands, 4.
Ranworth, 65.
„ Broads, 4.
Read, C. S., 92, 117.
Reading Beds, 31.
Re-constructed Chalk, 106, 135, 155.
Redman, J. B., 185.
Red Well Street, Norwich, 168.
Reedham, 79, 102, 103, 119, 142, 147.
„ Hills, 79, 103.
Reeve, James, 40, 57, 60, 63, 74, 82, 83, 193, 201.
Reid, Clement, 40, 50, 54, 56, 60, 65, 67, 85–88, 91, 103, 105–110, 113–115, 123, 124, 126–128, 133, 135, 136, 141, 142, 144, 145, 156–163, 165–167, 199, 200, 201, 203, 204.
Repps, 94.
Rhinoceros, 144.
Richards, W., 174.
Rigbone Hill, 109.
Ringsfield, 109, 128, 166.
Rigby, Dr. E., 124, 159, 169, 174, 175.
Rippon Hall, 163.
Rivers, 2, 147, 149.
River Gravel, 141.
„ Valleys, 129, 137, 143, 146.
Robberds, J. W., jun., 69, 80, 82, 83, 141, 147–149, 175, 176.
Robertson, D., 148, 192, 196.
Rockland St. Mary, 83, 84, 91, 110–112, 115, 116, 125, 192.
„ Broad, 4.
Roman kilns, 104, 114, 127.
Ronds, 4.
Rookery Farm, Plumstead, 75.
Roos Hall, 88.
Rosary Cemetery, Norwich, 165.
Rose, Caleb B., 7, 9, 20, 22, 87, 164, 176, 177, 179, 182–185, 188, 190, 192.
Round Towers of Norfolk, 129.
Royston, 135.
Runton, 129, 145.

S.

Saddle-shaped disturbance at Whitlingham, 134.
St. Benedict's Abbey, 65, 141, 147–149.
St. Faith's, Horsham, 61.
„ Norwich, 141.
St. James's Pit, Norwich, 13–17, 19, 23, 25, 28, 29, 72, 140.
St. John Ilketsal, 110, 162.
St. Peter's, Hoveton, 64.
St. Vedast, 141.
St. Walstan's Well, 168.
Salhouse, 38, 65, 99.
„ Broad 4.
Salt-works, 149.
Sandberger, Dr. C. L. F., 193, 203.
Sands, Glacial, 90–92.
Sand-galls, 9, 92, 138–140.
„ pipes, 138–140.
Sandstone, 93, 98, 104, 121, 126.
Sanford, W. A., 187.
Savin, A. C., 200.
Saxlingham, 38, 105, 125.
„ Nethergate, 55, 70.
„ Thorpe, 142.
Saxmundham, 156.
Scenery, 1, 146, 176.
Scott, Miss, 167.
Sco-Ruston, 93.
Scotton, 92.
Scrobicularia-bed, 83.
Sedgwick, Rev. Prof. A., 176, 183.
Seeley, Prof. H. G., 183–185, 186, 192.
Seething, 132, 191.
Sewage-works, Norwich, 124, 139, 144, 155.
Sharman, G., 10.
Sharpe, D., 10, 182.
Sheets Hill, 104, 132.
Shells. *See* Fossils.

Digitized by Google

Shepherd s Cottage, Hellesdon, 66, 67, 96.
Shipmeadow, 109, 128, 166.
Shottesham, 38, 71, 104, 113, 125, 169.
„ All Saints, 9.
„ St. Mary, 132.
Sizeland, 126, 133.
Skates Hill, 105.
Skertchly, S. B. J., 30, 91, 110, 111, 115, 116, 129, 136–138, 145, 198–202.
Smallburgh, 90, 94.
Smith, J. Toulmin, 10, 180.
„ William, 32, 39, 55, 80, 173, 174, 179, 183.
Smockmill Common, 71.
Soil, Analysis of, 94.
Sollas, Prof. W. J., 20, 21, 198, 203, 204.
Sorby, Dr. H. C., 21, 181.
Sothern, S. C., 60, 63, 71, 77, 82, 125.
Southwell, T., 148.
Southwood, 78, 101, 119.
Sowerby, J., 32, 82, 174.
„ J. de C., 115.
Spalding, F., 201.
Spelman, Sir H., 171.
Spinny, Thorpe, 99.
Spitalfields, 98.
Spixworth, 38, 61, 166.
Springs, Mineral, 168.
Spring Farm, Attlebridge, 66, 118, 130.
Sprows-pits, 122.
Sprowston, 14–17, 68, 90, 96, 116, 138, 166.
Squires, P., 170, 175.
Stalham Broad, 4.
Stark, W., 178.
Stevens, E. T., 193.
Stevenson, G., 175.
„ H., 193.
Stewpond Car, 59.
Stock, D., 85, 176.
Stockton, 107, 126, 166.
Stoddart, W. W., 190.
Stokesby, 120, 143.
Stoke Holy Cross, 8, 9, 10, 13–16, 19, 38, 55, 71, 104, 139, 140, 167.
Stone bed, 31, 39, 70, 75, 139.
Stone Hills, 8, 28, 67.
„ „ Farm, 67.
Stony Loam, 90, 91, 112.
Stow Park Farm, 108, 158.
Strata, Table of, 5.
Stratton, Long, 69, 117, 170.
„ St. Michael, 70, 113, 117, 127, 167.
„ Strawless, 38, 56.
Streak in Boulder Clay, 124.
Strumpshaw, 1, 25, 77, 90, 100, 114, 119, 129.
Strumpshaw Broad, 4.
Stuart, Prof., 198.
Subsidences of land, 9, 139.
Surlingham, 31, 34, 39, 55, 91, 110–112, 116, 142, 152, 196.
„ St. Mary, 83, 132.
„ St. Saviour, 5, 83, 125, 132.
Surlingham Broad, 4.
Sutcliff, Mr., 156, 166.
Sutherland, Dr., 137.
Sutton, F., 121, 154, 155, 163, 186, 202.
Sutton, 65, 94.
Swaffham, 114.
Swainsthorpe, 113, 116, 122, 131, 134, 135, 187.
Swan, Mr., 159.
Swan Bank, 141.
Swan's Grove, 132.
Symonds, Rev. W. S., 190.

T.

Tasburgh, 9, 70, 127, 129, 132, 134, 147.
Tase, River; *see* Tese.
Tate, Prof. R., 24.
Taverham, 93, 130, 134, 156, 167.
Taylor, I. O. Howard, 75.
„ J., 177.
„ Dr. J. E., 10, 25, 33, 36, 40, 55, 68, 71, 72, 75, 80–82, 93, 97, 105, 112, 118, 121, 134, 137, 139, 140, 144, 148, 155, 165, 186–188, 190–195, 199.
Taylor, R. C., 23, 32, 55, 72, 81, 82, 116, 138, 147–149, 165, 175, 176.
Teall, J. J. H., 197.
Telford, T., 175.
Tellina Balthica, 33. 37.
„ „ Crag, 32.
Tertiary, 31.
Tese, River, 2, 147.
„ Valley, 152.
„ „ Crag of the, 69.
Tharston, 14, 69, 113, 123, 127, 167.
„ Furze Hill, 9, 21, 69, 127–129, 131, 132.
Thetford, 110, 112.
Thickthorn, 122, 130.
Thomson, Sir C. Wyville, 22.
„ Dr. R. D., 180.
Thomsonite, 170.
Thorpe (Norwich), 2, 10–19, 24, 26, 30, 33–35, 38, 39, 41–55, 78, 82, 98, 116, 118, 138, 140, 142, 144, 151, 170, 178, 193, 194.
Thorpe Hamlet, 2, 4, 8, 10–19, 26–28, 72.
Thorpe Lime Kiln, 8.
„ Station, Norwich, 141.
Thorpe-next-Haddiscoe, 106.
Thurlton, 126.
Thurne, 94, 120.
„ River, 2.
Thurton, 93, 105, 125, 132.
Thwaite, 117, 167.
„ Spring, 105, 168.
Tidal Influence, 3.
Tindall, E., 184.
Tivetshall, 117.
Todd, J. T., 55, 166.
Toft Monks, 86, 106, 126.

Digitized by Google

Topcroft, 117.
Trevelyan, Sir W. C., 180.
Trimmer, Joshua, 24, 75, 76, 126, 140, 143, 179, 181, 182, 187.
Trimmer, Rev. K., 187.
Trimmingham, 20, 136.
Trowse, 8, 12–18, 21, 23, 24, 38, 80, 104, 116, 124, 134, 138, 151, 152, 190, 202.
Trowse, Disturbance of Chalk at, 134–138.
„ Hall, 80.
„ Junction, 120.
„ Millgate, 121, 144.
Tuck's Wood Farm, 120.
Tunstall, 66, 101, 155.
Tunstead, 92, 94.
Turner, Dawson, 57, 58.
Tyler's Hill, 85.
Tylor, A., 195.

U.

Uncallow, 28, 57.
Underwood's Pit, 5, 6.
Uplands Mill, 157.
Upton, 90, 99, 100, 102, 103, 116, 117, 119.
Ussher, W. A. E., 84.
Utting, S. W., 69, 185, 143, 164.

V.

Valley Gravel, 141.
Valleys, Denudation of, 129, 137, 146.
„ Depth of, 143.
Vincent, Rev. W., 76.
Vivianite, 170.

W.

Wacton, 117.
Walcott, M. E. C., 183.
Walford, C., 149.
Walker, C., 199.
Wallich, Dr. G. C., 21, 22, 204.
Walsams Wells, 168.
Walsham, South, 34, 66, 90, 100, 103, 119, 149.
„ Broad, 4.
Wash Farm, 91.
„ Lane, 110.
„ „ Farm, 109, 128.
Water lane, Costessey, 118.
Water Supply, 154.
Waterloo, 61.
Wattle, 117.
Waveney River, 3, 176.
„ Valley, 141, 153.
Waveney Valley, Crag of the, 38, 85.
Waxham, 148, 153.
Wells (Water), 154.
„ Natural, 168.
Wensum, River, 2, 155.
„ Valley of, 146, 152, 196.
„ „ Crag of the, 38, 66.
Westleton Beds, 31, 33, 59, 73, 85.
Weston, 110.
Weybourn, 91.
„ Crag, 32.
Weybrigg, 148.
Whitaker, William, 9, 23, 66, 67, 75 80, 105, 112, 118, 123, 135, 140, 156, 164, 166, 171, 201.
White earth pit, Rockland, 84, 112.
Whitesley Sound, 4.
Whitlingham, 8, 12, 13, 14, 16, 18, 19, 23, 24, 30, 33, 38, 39, 42–55, 80, 82, 137–139, 178, 189.
Whitlingham, Cave, 29.
„ Disturbance of Chalk at, 134, 135, 136.
Wickhampton, 79.
Wigham, J. B., 68, 178.
„ R., 40, 55.
Wilson, P., 185.
Wiltshire, Rev. T., 183, 192.
Winston Hall, 107.
Winterton, 148.
Wiseman, B., 173.
Witton, 2, 76, 118.
Womack Broad, 4.
Wood, Searles V., 33 37, 40, 41, 44, 45, 52, 56, 57, 60–62, 74, 76, 82, 86, 156, 178, 179, 181, 187, 195, 199, 202.
Wood, Searles V., jun. 33, 36, 40, 60, 71, 73, 74, 81, 83, 85, 90, 95, 96, 100, 111, 116, 118, 124, 128, 129, 131, 136, 137, 185–188, 190–196, 198, 199, 201, 203.
Woodbastwick, 65.
„ Decoy, 4.
„ Hall, 9.
Woodlands, 1.
Woodrow, Mr., 148.
Woods End House, 82.
Woodton, 85, 107, 132.
Woodward, B. B., (sen.), 177, 180.
„ B. B., (jun), 84, 204.
„ Dr. Henry, 28, 63, 190.
„ Dr. John, 32, 38, 172.
„ Samuel, 10, 21, 24, 26, 28, 29, 32, 37, 40, 41, 44, 57, 58, 69, 72–76, 80, 82, 83, 85, 114 –116, 121, 124, 125, 129, 138, 143, 147, 148, 167, 170, 173, 176, 177, 180, 202.
Woodward, Dr. S. P., 8, 10, 17, 20, 25, 28, 32, 33, 40, 56, 69, 71, 74, 76, 115, 179, 182, 184, 185.
Woolpit, 103.
Woolwich and Reading Beds, 31.
Wren Park, 67.
Wrenningham, 129, 131, 167.
Wright, Dr. T., 10, 17, 185.
Wroxham, 5, 31, 33, 36, 42–54, 59, 62, 142, 143, 191, 196, 197.
„ Broads, 4.
„ Old Hall, 29.

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Wroxham Station, 64.
Wyatt, J., 189.
Wymondham, 128, 180.

Y.

Yare, River, 2, 147, 176.
„ Valley, 141, 152.
„ „ Crag of the, 38, 68.
„ „ Denudation of the, 124.
Yarmouth, 31, 95, 146.
Yelloly, Dr., 69.
Yelverton, 117, 124.
Youell, Mr., 160, 161.
Young, A., 117, 173.

Z.

Zones in the Chalk, 20, 25.
„ in the Crag, 33, 36, 37, 82.

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Fig. 2. Section from Earlham to Acle.

Fig. 1. Section across Norwich.

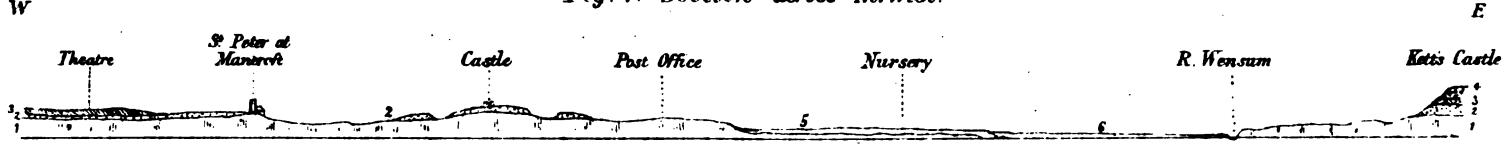

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PLATE I.

FIG. 1.—SECTION ACROSS NORWICH. (*See* p. 4.)

Distance, one mile.

6. Alluvium.
5. Valley gravel.
4. Sand and gravel - - - - - - } Glacial Drift.
3. Brickearth (stony loam) - - - - - }
2. Upper Crag (Norwich Crag Series).
1. Chalk with flints.

FIG. 2.—SECTION FROM EARLHAM TO ACLE, TO SHOW THE INCLINATION OF THE CHALK, AND THE PROBABLE POSITION OF THE EOCENE STRATA. (*See* pp. 5, 9, 31.)

Scale, 4 miles to one inch.

5. Glacial drift and upper crag.
4. Eocene strata?
3. Chalk.
2. Upper greensand and gault.
1. Unknown strata. (Palæozoic?)

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PLATE II.

FIG. 3.—PIT NEAR ST. MATTHEW'S CHURCH, THORPE HAMLET; CALLED ALSO THE BISHOP'S BRIDGE PIT, OR LOLLARD'S PIT. (*See* pp. 5, 30, 73.)

6. Sand and coarse gravel	Glacial Drift.
5. Brickearth (stony loam)	
4. Pale grey and yellow sand and fine shingle	Upper Crag.
3. Streaks of laminated clay	
2. False-bedded brown and yellow sand and shingle, with "stone-bed" at base	
1. Chalk with flints.	

FIG. 4.—SECTION AT COLTISHALL. (*See* p. 59.)

4. False-bedded pebble-gravel and sand	Upper Crag.
2. Laminated clay, with bed of sand (3)	
1. False-bedded sand, gravel, and shell-beds (s), with seams of clay and clay pebbles	
A. Chalk with flints and paramoudras.	

FIG. 5.—PIT NEAR WROXHAM PARK. (*See* p. 62.)

4. Sand and pebbly gravel	Upper Crag.
3. Shell-bed (impersistent), sand and gravel	
2. Laminated clay and sand	
1. Sand and shell-bed	
A. Chalk with flints.	

FIG. 6.—PIT NORTH-WEST OF SHEPHERD'S COTTAGE, HELLESDON. (*See* p. 66.)

8. Warp.	
7. Fine pebble-gravel	Glacial Drift.
6. Stony loam	
5. Yellow sand and laminated clay	Upper Crag.
4. Yellow and white sands, with irony veins	
3. Fine gravel and sand	
2. Rather coarse pebble-gravel and sand	
1. Pebble-gravel or shingle made up chiefly of flint, with a few pebbles of quartz and quartzite. Veins of ironstone	

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Fig. 3 Pit near Thorpe Hamlet Church

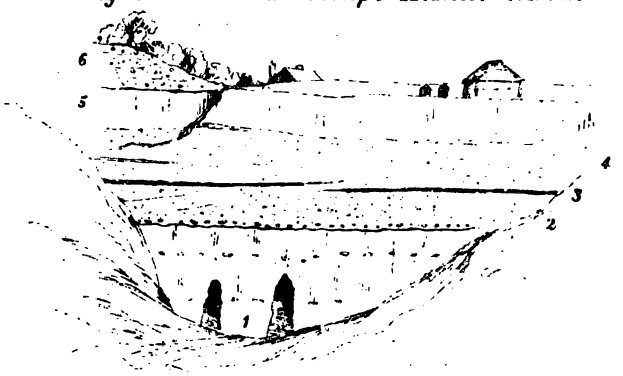

Fig. 4. Section at Coltishall

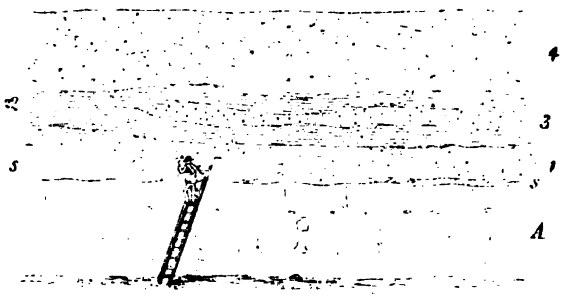

Fig 5. Pit near Wrackam Park.

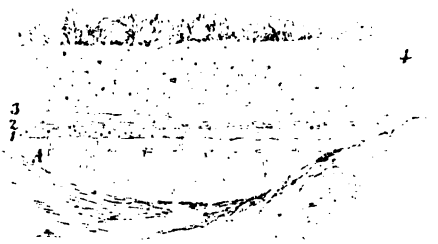

Fig. 6. Pit N.W. of Shepherd's Cottage, Hellesdon.

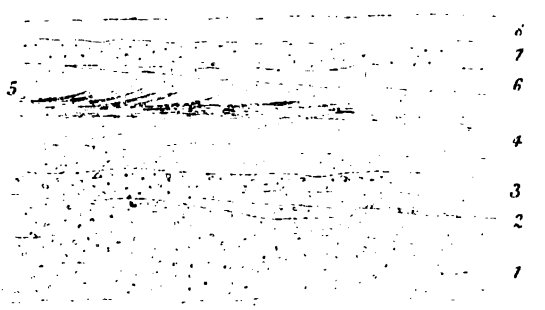

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Fig 7. Section at Hartford Bridge

Fig. 8. Section at the Thorpe Lime-kiln near Norwich

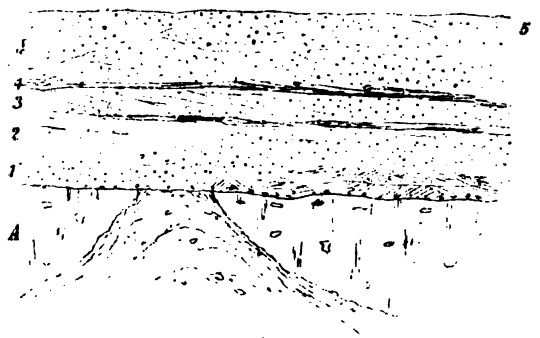

Fig. 9. Section at Whitlingham.

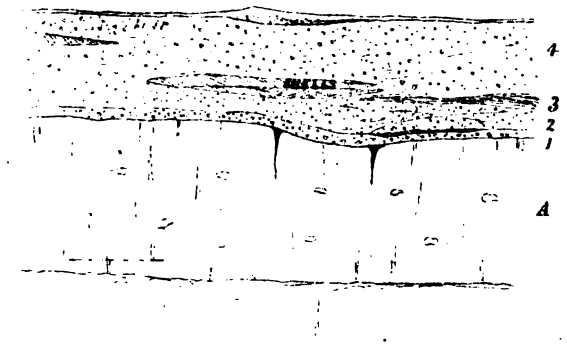

Fig. 10. Section at Tharston Furze Hill.

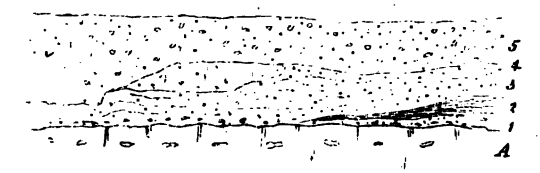

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PLATE III.

FIG. 7.—SECTION AT HARTFORD BRIDGE. (*See* pp. 34, 68.)

4. Pebbly gravel - - - - - - -
3. Wedge of pebbly gravel - - - - - - -
2. Laminated clay, with nests and veins of sand and fine gravel dovetailing into the pebbly gravel - - - - } Upper Crag.
1. Sand and shingle.
A. Chalk with flints.

FIG. 8.—SECTION AT THE THORPE LIME-KILN, NEAR NORWICH. (*See* p. 74.)

5. Irregular sandy capping - - - - - -
4. False-bedded sand and shingle, formed chiefly of flint and quartz, hardened in place and at various levels into a black ironstone-conglomerate or "ironpan," which contains casts of shells -
3. False-bedded sand and pebbly gravel, with irregular seams of micaceous sandy clay; shells at base - - - - } Upper Crag.
2. White and buff false-bedded sand, with shell-patches - -
1. Rolled flints and clay, with sand, pebbles, and shells, "Stone-bed" - - - - - - - -
A. Chalk with flints and paramoudras, 20 feet shown.

FIG. 9.—SECTION AT WHITLINGHAM. (*See* p. 81.)

4. Pebbly gravel and sand, with seam of shells - - -
3. Laminated clay and seam of shells - - - - } Upper Crag.
2. Sand and pebbly gravel, with patches of shells - - -
1. "Stone-bed."
A. Chalk with flints.

FIG. 10.—SECTION AT THARSTON FURZE HILL. (*See* pp. 69, 131.)

5. Coarse flint-gravel.
4. Chalky Boulder Clay.
3. Buff and brown false-bedded sands.
2. Laminated clay.
1. "Stone-bed."
A. Chalk with flints.

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PLATE IV.

FIG. 11.—SECTION AT SURLINGHAM WOOD. (*See* pp. 84, 116.)

5. Warp.
4. Brown clay, sand, and gravel, contorted - - - -
3. Sand in which bones have been found - - - -
2. Laminated clay and sand - - - - - -
1. White false-bedded sand - - - - -

} Upper Crag.

FIG. 12.—SECTION AT "MACKIE'S NURSERY," MILE END, ON THE IPSWICH ROAD, NORWICH. (*See* pp. 93, 120.)

4. Soil.
3. Red and brown sand, gravelly, and with small chalk pebbles -
2. Chalky Boulder Clay - - - - - -
1. False-bedded sand - - - - - -

} Glacial Drift.

FIG. 13.—PIT SOUTH-EAST OF HAMLINGTON CHURCH. (*See* pp. 99, 103, 119.)

D. Gravelly soil.
C. Chalky Boulder Clay - - - - - -
B. Buff false-bedded sand - - - - - -
A. Brickearth (stony loam). - - - - -

} Glacial Drift.

FIG. 14.—PIT NORTH-WEST OF UPTON CHURCH. (*See* pp. 90, 100, 103, 119.)

3. Chalky Boulder Clay - - - - - -
2. Sand - - - - - - - -
1. Brickearth (stony loam), with nests of sand - - -

} Glacial Drift.

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Fig 11. Section at Sudbingham Wood.

Fig. 12. Section at Mackie's Nursery, Norwich.

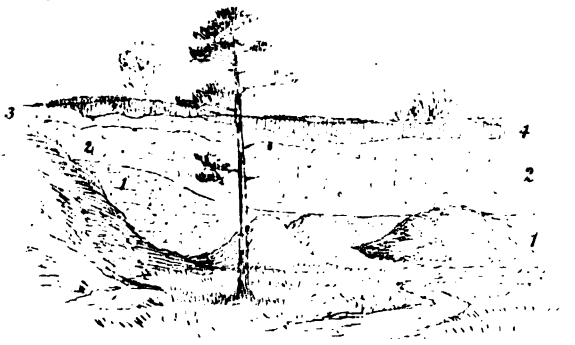

Fig. 13. Pit South-east of Hamlington Church

Fig 14. Pit North-West of Upton Church

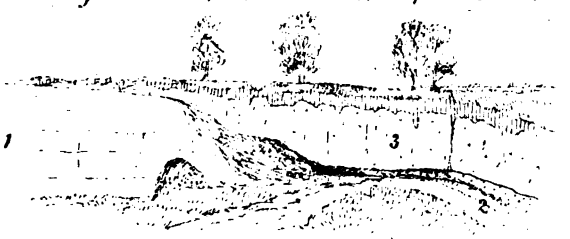

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Fig. 15 White Earth Pit, Rockland (Pit E. on Map)

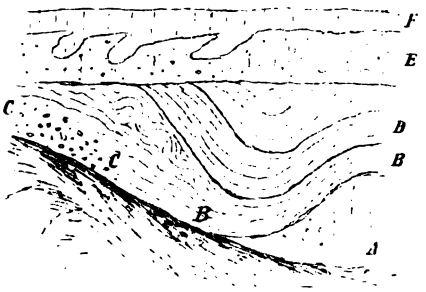

Fig 16. Map of part of Surlingham & Rockland.

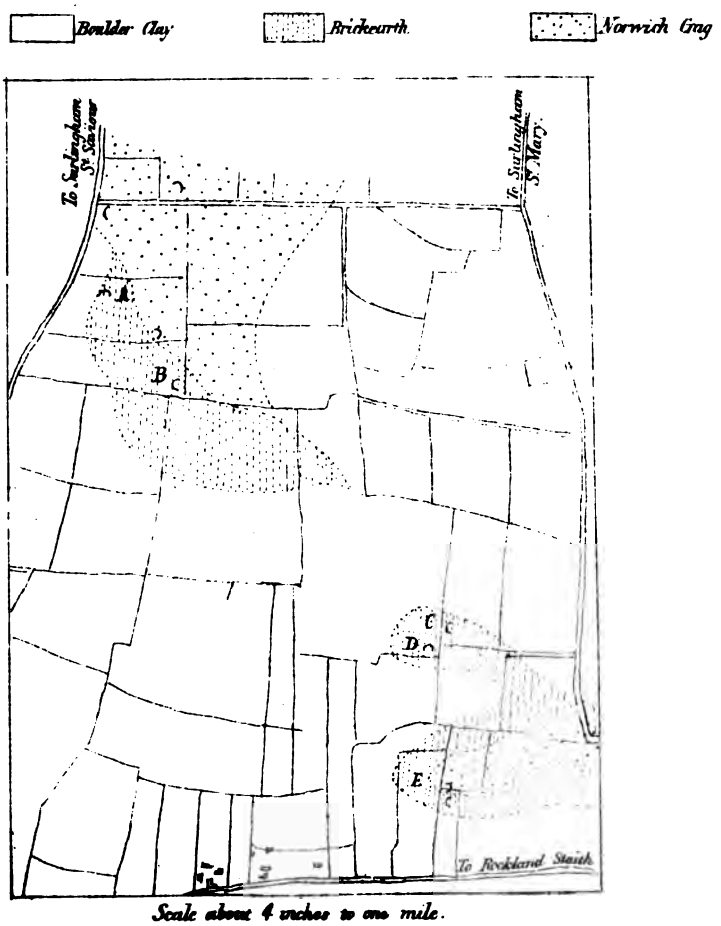

PLATE V.

FIG. 15.—WHITE EARTH PIT, ROCKLAND. (Pit E. on Map, fig. 16.)

F. Loamy soil.		
E. Brown clay with patches of Chalky Boulder Clay	-	-
D. Blue clay	-	-
C. Chalky gravel	-	-
B. Greyish yellow laminated clay (contorted in places)	-	-
A. Chalky Boulder Clay	-	-

} Glacial Drift.

FIG. 16.—MAP OF PART OF THE PARISHES OF SURLINGHAM AND ROCKLAND. (*See* p. 111.)

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PLATE VI.

FIG. 17.—SECTION AT SURLINGHAM; PIT A. ON MAP, FIG. 16, PLATE V.
(*See* pp. 111, 116.)

4. Brown clay and gravelly loam resting in hollows on bed below, with patches of Chalky Boulder Clay at the western end -	Glacial Drift.
3. Very stiff unctuous blue clay, with streaks of mottled reddish-brown clay, micaceous and sandy in places, rudely laminated. Alternations of blue and brown clay - - - -	
2. Brown and yellowish-grey laminated micaceous sand and clay, with hard-jointed beds - - - - - -	
1. Yellow sand - - - - - - - -	Upper Crag.

FIG. 18.—SECTION AT THE BRICKYARD BY HOME COTTAGE, SPROWSTON.
(*See* p. 97.)

b. Stratified gravel and sand, in places much false-bedded - -	Glacial Drift.
a. Stony loam containing pockets and contorted nests of buff sand, with carbonaceous specks. The loam passes downwards into a bluish-grey chalky clay, and attains a thickness of 30 feet (base not seen) - - - - - -	

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Fig. 18. Section at the Brickyard by Home Cottage Sprowston.

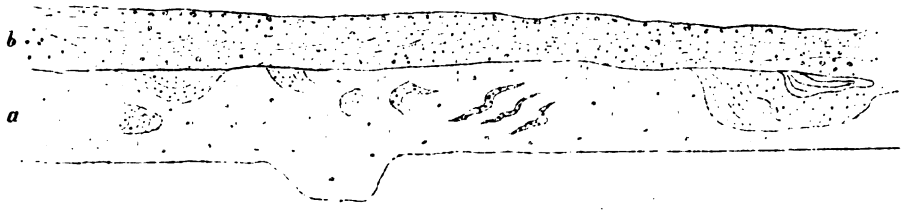

Fig. 17. Section at Surlingham. (Pit A on Map, Plate VI.)

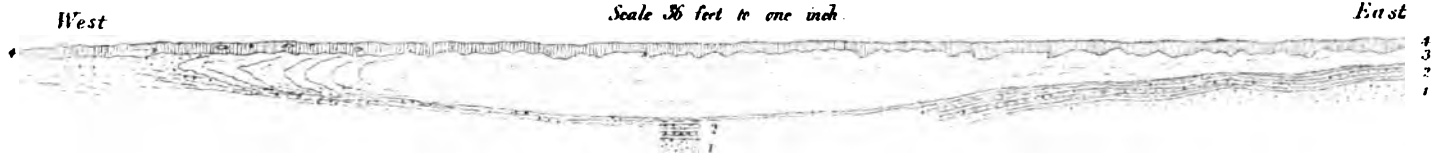

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Fig. 19. Section at Hethersett

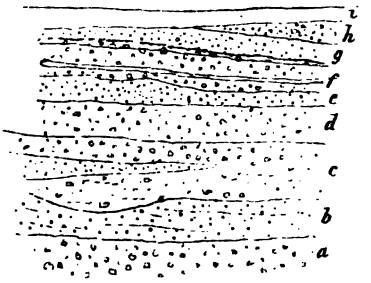

Fig. 20. Section at the Brickyard South of Swainsthorpe.

Fig. 21. Railway-cutting west of Hapton.

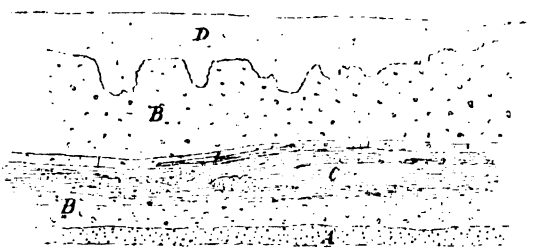

Fig. 22. Railway-cutting near Low End, South of Hapton

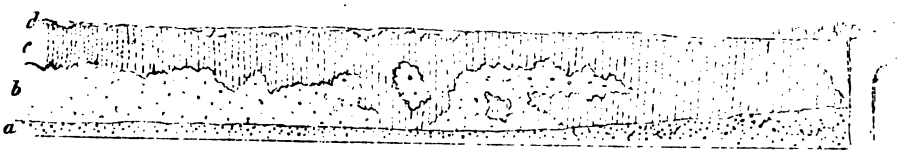

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PLATE VII.

FIG. 19.—SECTION AT HETHERSETT. (*See* pp. 90, 131.)

i. Soil	Glacial Drift.
h. Angular and rolled gravel	
g. Coarse buff and brown sand	
f. Angular and rolled gravel and sand	
e. Sand	
d. Gravel	
c. Very coarse boulder gravel and finer gravel, with included bed of sand	
b. Buff sand, with seams of chalky sand	
a. Coarse gravel (base not seen)	

FIG. 20.—SECTION AT THE BRICKYARD SOUTH OF SWAINSTHORPE RAILWAY STATION; IN THE PARISH OF NEWTON FLOTMAN. (*See* pp. 71, 113, 116.)

5. Brown clay	Glacial Drift.
4. Chalky Boulder Clay. Veins of chalky sand, impersistent	
3. Brickearth; bluish-grey clay and loam, with few stones, many nests of sand, much contorted	
2. Sand and loam in alternate bands; laminated and slightly contorted	
1. False-bedded buff and white sand, with few stones	Upper Crag.

FIG. 21.—RAILWAY-CUTTING WEST OF HAPTON. (*See* p. 124.)

Height, about 25 feet. Distance, about 1 chain.

D. Brown loam	Glacial Drift.
C. Bluish-grey mud, with streaks of Chalky Boulder Clay	
B. Chalky Boulder Clay	
A. Sands	Upper Crag.

FIG. 22.—RAILWAY-CUTTING NEAR LOW END, SOUTH OF HAPTON. (*See* p. 123.)

Height, from 25 to 30 feet. Length, about 6 chains.

d. Gravelly soil	Glacial Drift.
b. Chalky Boulder Clay passing into *c.* Brown clay or stony loam	
a. Grey or yellow sands and pebbly gravel; in places contorted	Upper Crag.

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PLATE VIII.

FIG. 23.—SECTION NEAR KESWICK MILL. (*See* p. 140.)

C. Chalky gravel and rubble.
B. Coarse and fine gravel and sand.
A. Chalk with flints.

FIG. 24.—SECTION OF A CHALK PIT AT TROWSE. (*See* pp. 80, 135.)

I. Surface-soil. (2 to 3 ft.)	
H. Brown clay - - - - - - -	Glacial Drift.
G. Sand with veins of fine gravel (10 ft.) - - - -	
F. Coarse gravel - - - - - - -	
E. Sand with pebbly seams, shells, and bands of clay - -	Upper Crag.
D. Laminated clay, with "stone-bed" and shells at base - -	
C. Chalky loam, lying on atmospherically eroded surface of B. -	Glaciated Chalk.
B. Re-constructed chalk, with drift pebbles - - - -	
A. Chalk, with flints and paramoudras; into which galleries have been driven.	

FIG. 25.—SECTION OF A CHALK PIT AT TROWSE. (*See* pp. 135, 136.)

G. Chalky marl - - - - - - -	Glaciated Chalk and Glacial Drift.
F. Sandy and pebbly marl, and re-constructed chalk - -	
E. Rubbly chalk and sand - - - - - -	
D. Laminated loam and marl, contorted - - -	
C. Sandy pockets - - - - - - -	
B. Chalk, with broken flints (disturbed) - - - -	
A. Chalk, undisturbed.	

Total thickness of beds shown, about 50 feet.

(The Section, fig. 24, is seen in the distance.)

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Fig. 23. Section near Keswick Mill.

Fig. 24. Section of a Chalk-Pit at Trowse

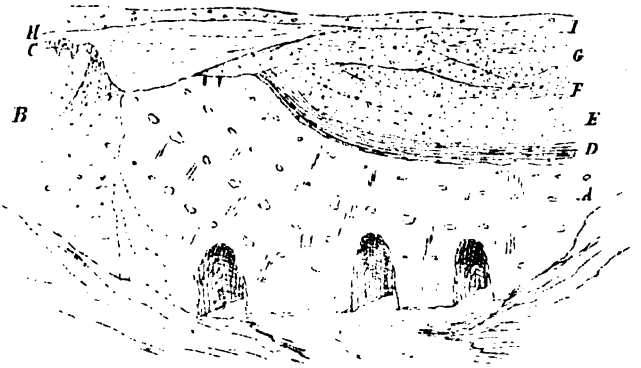
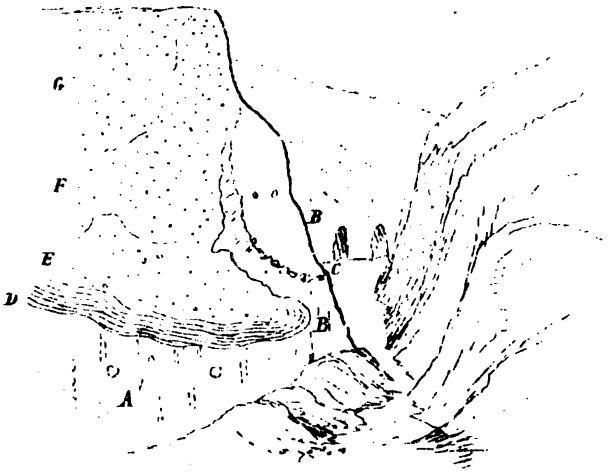


Fig. 25. Section of a Chalk-Pit at Trowse.



88

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